PB-232 921

STUDY AND EVALUATION OF COMPUTER CARPOOL PROGRAMS IN CERTAIN METROPOLITAN AREAS

GCA Corporation

PREPARED FOR

Environmental Protection Agency

April 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-450/3-74-041

2.

3. RE
PB 232 921

4. TITLE AND SUBTITLE
Study and Evaluation of Computer Carpool Programs in Certain Metropolitan Areas

5. REPORT DATE
April 1974

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
David A. Bryant

8. PERFORMING ORGANIZATION REPORT NO.
GCA-TR-74-8-G

9. PERFORMING ORGANIZATION NAME AND ADDRESS
GCA Corporation
Burlington Road
Bedford, Massachusetts 01730

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-02-1337, Task Order No. 3

12. SPONSORING AGENCY NAME AND ADDRESS
Environmental Protection Agency
Office of Air Quality Planning and Standards
Strategies and Air Standards Division
Research Triangle Park, North Carolinia 27711

13. TYPE OF REPORT AND PERIOD COVERED
Final - April 1974

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Study initiated to develop and present technique for initiating computer/carpool programs.

16. ABSTRACT

The report methodology is adopted in certain metropolitan areas to arouse public interest and support for carpooling by the use of computer matching to reduce the total number of vehicles committed to work trips, reduce the demand for scarce motor fuels, and reduce vehicle miles traveled. All these combined will contribute to the improvement of air quality in congested work areas in metropolitan centers.

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Carpool Systems Matching Method Data Base Incentives - Disincentives		

18. DISTRIBUTION STATEMENT
Release Unlimited

19. SECURITY CLASS (This Report)
Unclassified

20. SECURITY CLASS (This page)
Unclassified

21. NO. OF PAGES
184

22. PRICE
$5.50

EPA Form 2220-1 (9-73)

GCA-TR-74-8-G
April 1974

STUDY AND EVALUATION OF COMMUTER CARPOOL PROGRAMS IN CERTAIN METROPOLITAN AREAS

By

David A. Bryant
GCA Corporation
GCA/Technology Division
Bedford, Massachusetts 01730

Contract No. 68-02-1337
Project 300927
Task Order No.3

Project Officer

David Tamny
Land Use Planning Branch
Strategies and Air Standards Division
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Prepared for
U.S. Environmental Protection Agency
Research Triangle Park
North Carolina 27711

iv

ABSTRACT

This report presents the results of a survey and evaluation of computer-assisted systems designed to increase the amount of carpooling in several metropolitan areas. The report considers most of the major carpool systems which serve either an entire metropolitan region or a large number of employers in a region and which were well underway by early 1974.

In describing existing systems, the report treats not only the actual computer programs used for matching prospective carpool partners but also discusses organization, history, marketing, incentives and disincentives, and results to date. In addition, the report contains general discussions of related elements such as legal questions, insurance, benefits of carpools and of carpool systems, and the theoretical potential for carpooling. Theoretical and general considerations are compared with actual practice throughout the report.

From the review of experience to date it is concluded that certain types of carpool systems have the potential for increasing the amount of carpooling and reducing the amount of air pollution from automobiles, throughout a metropolitan area. Additional study and research on carpool systems are recommended, however, because computer-aided carpool systems are relatively new and were found to be rapidly evolving.

Included in the report are recommendations for organizing and operating a carpool system to serve a metropolitan area. These recommendations

were developed largely from analysis of the actual carpool system experience reviewed for the report.

In addition, an annotated bibliography and list of information sources are provided to aid those who wish to organize, design, operate, or study carpool systems.

This report was submitted in fulfillment of Task Order Number 3, Contract Number 68-02-1337, by the GCA Corporation, GCA/Technology Division, under the sponsorship of the U.S. Environmental Protection Agency. Work was completed in April 1974.

CONTENTS

		Page
Abstract		ii
List of Figures		v
List of Tables		vi
Acknowledgments		vii
Sections		
I	Background on Carpool Systems	1
II	Benefits of Carpool Systems	7
III	Matching Method and Data Base	11
IV	Matching Software	58
V	Organization of Carpool Systems	91
VI	Marketing	100
VII	Incentives and Disincentives	116
VIII	Review of Other Issues	128
IX	Estimating the Potential for Carpool Systems	134
X	Summary and Recommendations	148
XI	References	163
XII	Annotated Bibliography	167

FIGURES

No.		Page
1	Geographic Coding Concepts	61
2	Cluster Search Method in Denver, Colorado, Carpool Matching Program	83
3	Vector Search Method in Denver, Colorado, Carpool Matching Program	84

TABLES

No.		Page
1	Air Quality Control Regions with Carpool Systems in State Implementation Plans as of 30 November 1973	4
2	Characteristics of Selected Boston Area Employer-Operated Destination-Based Carpool Systems	20
3	Summary of Incentives	127
4	Differences in Travel Behavior between Carpools and Non-Poolers on Hollywood Freeway, 1972	140

ACKNOWLEDGMENTS

Many individuals and several organizations have provided valuable assistance and information to this study; for these contributions GCA/Technology Division extends its sincere gratitude.

Project direction and guidance were provided by Mr. Dave Tamny of the Land Use Planning Branch, EPA, Durham, North Carolina.

SECTION I

BACKGROUND ON CARPOOL SYSTEMS

BASES FOR THE INTEREST IN CARPOOL SYSTEMS

The Clean Air Amendments of 1970

The present interest of the U.S. Environmental Protection Agency (EPA) in carpool* systems originates from the Clean Air Amendments of 1970 (Public Law 91-604). Section 109 of the amended Clean Air Act requires the Administrator of EPA to prescribe ambient air quality standards for air pollutants. Section 110 of the Act requires that every state prepare and submit to EPA an implementation plan by which the air quality standards will be met. Section 110 (a)(2)(B) specifically allows the state implementation plans to include controls on transportation and land use.[1]

As the state implementation plans were developed and submitted to EPA, the Administrator of EPA designated the regions where transportation control plans would be needed to meet air quality standards for carbon monoxide and oxidants. As the development of these plans has progressed, the list of regions needing transportation control plans has steadily lengthened. At the present time more than 40 air quality control regions will require transportation control plans; many of these plans have been prepared, submitted to EPA, and approved.

---

* The focus of this report is carpools, but much of the information also would apply to vanpools or buspools. Refer to page 120 for further comment on vanpools and buspools.

Fuel Shortages

In addition to the interest in carpooling provided by the Clean Air Amendments of 1970, the shortages of automotive fuels in some areas of the U.S. during 1973 and early 1974 provided additional impetus to organized carpool systems. In several cities, new carpool systems were organized by radio and television stations, major employers, civic groups, or government agencies, as part of the effort to cope with the fuel shortages. Some of these efforts were directed towards the general public, whereas others were intended for particular groups, such as employees of the sponsoring employer. Several of these programs have enlisted thousands of participants.

Also in response to the fuel shortages, the Congress passed the Emergency Highway Energy Conservation Act. Among other steps, this Act authorized the U.S. Secretary of Transportation to (1) provide financial support to "demonstration projects designed to encourage the use of carpools in urban areas" and (2) study (in cooperation with other agencies including EPA) what measures "might lead to significant increases in carpool ridership in urban areas..."[2]

As a result of this Act, the U.S. Department of Transportation (DOT) organized and conducted a series of carpool seminars throughout the U.S., in which DOT presented guidance to assist state and local agencies to establish carpool systems for the purpose of conserving fuels. The Highway Users Federation for Safety and Mobility (HUFSAM) is conducting a similar series of seminars aimed at industrial organizations.

As part of the U.S. Government's effort, the Secretary of Transportation asked that each regional transportation planning agency submit an emergency transportation program by May 1, 1974, in which the agencies specify low-cost, short-term projects which will help to reduce transportation fuel consumption. Such projects may include carpool matching systems, exclusive lanes for carpools and/or buses, carpool parking lots, and similar actions. Federal funds were made available for some such emergency projects, including carpool matching systems as mentioned above.[3]

As a result of all these efforts, there is a great deal of activity related to organizing carpool systems at the present time throughout the U.S. Thus it can be seen that, as a result of (1) the efforts to comply with Clean Air Amendments of 1970 and (2) the efforts to cope with present fuel shortages, there are dozens of cities in the nation which either have or shortly will have organized carpool matching systems and campaigns to organize carpools. This report will examine the experience to date with such carpool programs and identify the characteristics of an effective program.

STATUS OF CARPOOL SYSTEMS

Many of the transportation control plans (TCP's) proposed or approved to date have included carpool matching systems as one of the strategies to reduce the amount of pollutant emissions from motor vehicles. Some of the Air Quality Control Regions (AQCR's) with carpool systems in the implementation plans are listed in Table 1.

Most of the promulgated plans do not, however, include detailed requirements for establishing the carpool matching systems. For example, the published regulations for the Boston AQCR state:

> § 52.1138 Regulation for computer carpool matching.
>
> (a) "Carpool matching" means assembling lists of commuters with similar daily travel patterns and providing a mechanism by which persons on such lists may be put in contact with each other the purpose of forming carpools.

Table 1. AIR QUALITY CONTROL REGIONS WITH CARPOOL SYSTEMS IN STATE IMPLEMENTATION PLANS AS OF 30 NOVEMBER 1973

State	AQCR
Arizona	Phoenix-Tucson
California	San Francisco Bay Area Metropolitan Los Angeles San Diego Sacramento Valley San Joaquin Valley
District of Columbia	National Capital
Indiana	Metropolitan Indianapolis
Maryland	Metropolitan Baltimore
Massachusetts	Hartford-New Haven-Springfield Boston
New Jersey	New York, New Jersey, Connecticut, Metropolitan Philadelphia
Pennsylvania	Metropolitan Philadelphia Southwestern Pennsylvania
Texas	Houston-Galveston Dallas-Fort Worth San Antonio
Washington	Puget Sound Eastern Washington Northern Idaho

Source: U.S. Environmental Protection Agency

(b) This section is applicable in the Boston Intrastate Region if the Automobile Legal Association/WBZ "Commuter Computer Club Car" is discontinued.

(c) The Commonwealth of Massachusetts shall, unless otherwise exempted by the Administrator on the basis of a finding of the continued existence of equivalent (private) service, establish a computer-aided carpool matching system that is conveniently available to the general public and to all employees of employers having more than 50 employees within the Intrastate Region who operate light-duty vehicles on streets and highways over which the Commonwealth has ownership or control. No later than 3 months after discontinuation of the "Commuter Computer Club Car," the Commonwealth shall submit legally adopted regulations to the Administrator establishing such a system. No provisions of such regulations shall have an effective date later than 3 months from the date of adoption. The regulations shall include:

(1) A method of collecting information that will include the following as a minimum:

(i) Provisions for each affected employee to receive an application form with a cover letter describing the matching program.

(ii) Provision on each application for applicant identification of commuting time, origin, and destination, and the applicant's desire to ride only, drive only, or share driving.

(iii) A computer method of matching information that will have provisions for locating each applicant's origin and destination within the Boston Intrastate and the Interstate Regions and matching applicants with similar origins and destinations and travel schedules and enabling the persons so matched to make contact with each other at the request of any one of them.

(iv) A method of providing continuing service such that the matched lists of

> all applicants are retained and made available for use by new applicants, application forms are currently available, and the master lists are periodically updated to remove applicants who no longer meet the governing criteria and add new applicants who do.
>
> (v) Designation of an agency or agencies responsible for operating, overseeing, and maintaining the computer carpool matching system.[4]

In short, the regulations require the Commonwealth of Massachusetts to make available a carpool matching system to all employers in the AQCR with 50 or more employees. The regulations specify the general types of information on which matches should be based, but otherwise are not very detailed regarding how such a system should be organized and run. Regulations for carpool matching systems in other AQCR's are similar.

Because such computer-based carpool matching systems are relatively new, and because the widespread use of organized carpooling has never before been attempted on this scale, there is a need for in-depth development of detailed guidelines for organizing carpool matching systems. This report is addressed to that need.

SECTION II

BENEFITS OF CARPOOL SYSTEMS

BENEFITS RELATED TO AIR QUALITY

There are a number of potential benefits associated with widespread use of carpools. Some of these are public benefits--that is, they accrue to society as a whole; and others are private benefits--that is, they accrue to the individuals involved.

Chief among the expected public benefits of widespread use of carpools would be benefits related to air quality. It is generally acknowledged that private passenger cars are the predominant source of several air pollutants in many urban areas.[5] Consequently, the use of carpools, or any action which reduces the number of vehicles being used, would reduce pollutant emissions and improve air quality.

More specifically, there are two ways in which the increased use of carpools would improve air quality. First, the use of carpools would result in fewer vehicles using the road system at any given time (during rush hours, for example). With fewer cars on the road at a given time there would be less congestion and improved traffic flow. Improving traffic flow, by increasing speeds and reducing the number of starts and stops, reduces the amount of pollutant emissions per vehicle-mile. Second, with fewer vehicles being used there will be less total pollution in a given geographical area.

Both these effects would be most pronounced in peak traffic periods, inasmuch as most carpool programs are intended for commuting to work. Total daily automotive pollution output could be reduced still further by carpools for non-work purposes, such as shopping, school, and recreation.

Another public benefit could be the use of widespread carpooling instead of an alternative transportation control strategy in those Air Quality Control Regions (AQCR's) which need transportation control plans in order to improve air quality enough to satisfy Federal standards. Carpooling may be more attractive to the public and more cost-effective than alternatives such as substantial and costly additions to mass transit systems. Furthermore, the use of carpools can be rapidly and readily instituted, whereas alternatives such as new transit systems require long periods of time to implement.

As an example, consider a hypothetical city in which 120,000 people now commute to work by car. Typically, such a city would have an average of about 1.2 persons in each passenger car used for commuting to work.[6] Thus in the hypothetical city there are 100,000 passenger cars used for travelling to work each day. Suppose further that in order to meet air quality criteria it is necessary to reduce the total amount of work-related travel by passenger cars in the metropolitan area by 10 percent, as one part of the transportation control plan. To achieve this reduction by shifting people to buses would require providing enough buses for 10 percent of the commuters, or 12,000 people. To carry 12,000 commuters each way to work in the peak hours would require 120 buses, assuming each bus could make two runs in the peak period and could carry 50 passengers. The capital cost of 120 buses would be approximately $5,000,000. Operating costs would include the wages for the drivers and dispatchers, plus fuel, maintenance, storage, licensing, and insurance for the buses.

As the alternative, the 12,000 commuters could be carried in carpools. On the average, the number of persons in each car would increase from 1.2 to 1.33, so on the average one car in three would have passengers. It would be necessary to match 12,000 riders with drivers. The public cost would be the cost of operating the carpool matching program and advertising campaign; in many cities this is being done at no charge as a public service by auto clubs, radio stations, or employers; elsewhere the cost is estimated to be less than $100,000 for a two-year initial effort.

This example, while simplified, demonstrates the attractiveness of carpooling as an element in the transportation control plan.

OTHER ADVANTAGES

Besides the air quality advantages of increased carpooling, there are other benefits as well, both public and private.

An important public benefit of carpooling could be reduced energy consumption, provided that the vehicles no longer being used for driving to work are not used for other, counter-productive trips. If leaving cars at home should lead to increased travel by members of the family besides those in carpools, total travel may not be reduced as much and air quality would not be improved very much. Net energy reduction from carpools will be greatest if such additional trips are discouraged, and if carpooling can actually result in reducing the number of cars in use (i.e., if some people reduce the number of cars they own). The Highway Users Federation has estimated that a 25 percent increase in carpooling would reduce the consumption of petroleum by nearly 2 percent.[7]

A private benefit of carpooling is the direct monetary savings for the commuter. Obviously the amount of savings would depend on many elements, such as car size, parking costs, number of people in carpool, distance driven, and so on. Compared to driving alone, carpooling reduces costs in direct proportion to the number in the pool. Carpooling is less expensive than transit in many cases, and also may be more convenient as well.

Additional benefits for the participants in carpools may occur as a result of campaigns to encourage carpools. Some employers provide incentives to carpoolers, such as cash payments, preferential parking, or flexible working hours. Government agencies can and do provide additional incentives, such as the use of exclusive highway express lanes, preferential treatment at interchange ramps, preferential parking in public facilities, and monetary incentives such as reduced tolls on turnpikes.

SUMMARY

Widespread use of carpools can provide substantial benefits both to the public and to the individuals involved. Carpooling systems offer an attractive and inexpensive alternative to other means of reducing air pollution through reductions in travel. The attractiveness of the use of carpools results in part from the ease with which they can be implemented, compared to alternatives such as enlarged transit systems.

SECTION III

MATCHING METHOD AND DATA BASE

INTRODUCTION TO MATCHING

General

Central to the discussion of a carpool system is the structure of the process by which prospective carpool members are identified to each other, or matched. In this matching process, information about people who have expressed an interest in carpools is manipulated in a way to identify likely candidates for carpools. Typically, the matching process uses information such as employee work schedules (starting and quitting times), home and work locations, and perhaps preferences regarding smoking and sharing driving responsibility.*

The success of a campaign to encourage carpooling is strongly dependent upon the number of potential carpools which can be identified by the matching process. The chance of identifying a potential match in turn depends upon how large the data base is (the data base is the collection of potential carpoolers) and upon the amount of variability in home addresses, work locations, work schedules, and preferences. For a given size data base, the chances of a match decrease rapidly with increases in the number of combinations of work schedules, home addresses, work locations, and preferences. For a fixed number of home addresses, work locations, schedules, and preferences, the chance of matching increases rapidly with the size of the data base. (These relationships are discussed in greater detail in Section IX.)

---

*Throughout most of this report, the carpool systems being discussed are intended to serve the journey to work. Carpool systems for other trip purposes are briefly discussed later in this Section (page 52).

Destination-Based Matching

In the past, most carpool systems were used for only one destination, and often for employees on only one or two work schedules. For example, a single employer would provide a system for his employees. With such a destination-based system the matching problem typically is reduced to that of identifying people who live near each other and desire to form a carpool. Relatively high chances of matching could result from even a few hundred employees at one site.

Regional Matching

With the current interest in encouragement of carpooling throughout an entire metropolitan area in order to achieve substantial reductions in pollutant emissions (and in fuel consumption), attention has focused on matching commuters throughout the area. This type of matching potentially could have a large data base but also is more complex than single-destination matching because now multiple destinations and multiple work schedules are added variables.

For example, a metropolitan area could be divided into a grid for the purposes of matching. Such a grid would typically have several hundred or even a few thousand elements. There may be 50 or more destinations (work locations). As many as 10 separate work schedules could be involved. Altogether, the number of combinations of home grids, destinations, and work schedules could be on the order of hundreds of thousands. Hence enormous additional complexity accompanies the expanded data base.

Combination Matching

A third type of matching system combines the features of the single-destination and regional systems. In a combination system matching is done for specific organizations or destinations and also for the region as a whole. The data on individual employers may or may not be part of the data base for regional matching. Such systems attempt to capitalize on the simplicity of destination-based matching while at the same time serving the smaller employers who require a regional data base for effective matching.

Because regional and combination matching systems are relatively new and involve potential complexity, this section will separately review the experience with destination-based, regional, and combination matching systems. In addition this section will discuss special-purpose matching for non-work purposes.

EXPERIENCE WITH DESTINATION-BASED SYSTEMS

General

Destination-based carpool matching systems have been in use for several years. Many systems have been manual, using self-service matching techniques based upon maps with pins and cards, or personalized matching through organization employee address files. In recent years, several employer-operated systems have been computerized for efficiency. The use of such systems was prompted by various circumstances. Probably the most common reason for initiating a destination-based carpool matching system in the past was parking limitations. For example, in Washington, D.C., carpool matching map systems have been common for many years because of the large numbers of people with common work locations combined with the lack of sufficient parking for all employees. Many Washington agencies have had a long-standing practice of preferential parking for carpools.

Destination-based systems are most commonly managed by an employer. Another arrangement is for several organizations in one building, or perhaps in a few buildings at one location, to pool their data and match together. Such systems can be operated by outside agencies as a service, also, as is the case with at least one of the broadcasting station systems currently in operation.

Destination-based systems have been proven in concept, are relatively simple to operate, and offer efficient matching with modest data bases. To illustrate the use of such systems, several cases will be reviewed.

Case Histories of Destination-Based Systems

General - This section will briefly summarize the experience with several destination-based systems. Because of the current surge of interest in carpooling, several recent reports have described numerous such systems in detail (see Bibliography). This report will not attempt to duplicate existing literature but instead will only highlight illustrative examples, and will concentrate on recent developments and on comparisons between destination-based and regional systems.

Federal Highway Administration, Washington, D.C. - One of the most widely used computer programs for carpool matching is one prepared by the U.S. Federal Highway Administration (FHWA). One of the first applications of this computer program was at the FHWA headquarters in Washington, D.C. In 1972 the FHWA used the program to provide lists of potential carpool partners to employees who expressed an interest in forming carpools. Shortly thereafter, a follow-up survey was done to assess the impact of the matching service.

The initial carpool questionnaire was sent to approximately 1,200 employees in one building. The forms were returned by 780 (65 percent) of the employees, of whom 550 (46 percent of the total) asked to be included in the matching process. The FHWA computer program was then used to prepare lists of potential carpool partners for each interested person. Reportedly, the majority of the participants received a substantial number of potential matches.

From the follow-up questionnaire (distributed two months after the carpool matching lists were distributed) the following results were reported by FHWA:

> " A. About 65 percent of FHWA employees commute in carpools.
>
> B. FHWA employees averaged 2.34 persons per auto before the program, 2.45 after. This small increase (5 percent) is thought to be due to the fact that the occupancy rate was so high to begin with that 'room for improvement' was slight....
>
> C. Bus ridership among the 980 respondents decreased from 197 (20 percent) before to 169 (17 percent) after. All of these 28 persons joined carpools. Only 18 of them, however, indicated that the matching program helped them. It is not known how many of these 18 would have joined a carpool without the help of the matching program....
>
> E. Of the 980 responding, 360 (35 percent) said they had benefited in one way or another from the program....
>
> F. Of the 360 who said they had benefited, 115 (30 percent) actually joined a new carpool, increased their existing carpool or changed members in their carpool due to the program."[8]

In this instance, carpooling was already so prevalent before the matching process began that little increase was observed in the amount of carpooling. Many people rearranged their carpools to be more convenient or otherwise suit them better, however, and others retained the matching lists for future reference for adjusting carpools.

Carpooling was very popular at FHWA headquarters before the matching process began; because of a shortage of parking spaces, carpools have been given preference in the FHWA parking garage. Consequently the matching process was not widely requested. Initially one might be surprised that only 46 percent of the employees expressed a desire to be matched, inasmuch as parking is in short supply; furthermore one would expect a public transportation agency to have a vested interest in demonstrating the usefulness of its own matching system. Many people may have declined to participate because they already were in an acceptable carpool. Consequently one might expect a higher rate of return under conditions where carpooling is not well established. Another way to look at this case is to conclude that carpooling will occur even without a sophisticated matching system if the incentives are adequate; in this case parking was substantially easier for carpools.

The same FHWA computer program has subsequently been distributed to many other agencies and firms. (This will be further discussed in Section IV.)

Burroughs Corporation - Another computer program now widely used is the "Operation Energy" program first used at the Medium Systems Plant of the Burroughs Corporation in Pasadena, California. Full details on the response rate from employees have not been published, but Burroughs reported that parking demand at the Pasadena plant dropped from 659 cars to 427 cars, a 35 percent decrease. This substantial reduction occurred as a result of a comprehensive campaign which included incentives such as preferential parking.[9,10] This reduction in parking demand is among the most dramatic observed changes in travel patterns reported as a result of carpool matching programs in the U.S.

Burroughs has made available their computer program and a description of their carpool campaign; copies have been distributed to numerous other firms and government agencies. The computer program, as well as other aspects of their campaign, will be further discussed in subsequent sections of this report.

Station WBBM, Chicago - Radio station WBBM in Chicago, a CBS network affiliate, has organized a different approach to destination-based carpool systems. Their carpool campaign, known as the "News Radio 78 Work Together/Ride Together" carpool system, operates solely on destination-based matching. Most of the other radio and television carpool campaigns have been based at least in part upon regional carpool matching. The station has arranged to perform the carpool matching service for a substantial number of companies and government agencies, with a potential data base of tens of thousands of Chicago area employees. The campaign was begun in the winter of 1973-1974, and has not been in operation long enough to permit an evaluation of its response rate. Apparently, however, the station has attracted firms with a significant fraction of Chicago area employment; if the matching process is widely used by the employees the campaign could be more effective than most regional carpool systems have been.

Each employer is separately matched in the WBBM system. All distribution and collection of questionnaires and publicity within the firm are handled by the employer, so in effect the campaign operates as a collection of separate destination-based systems. As an incentive to the companies, WBBM compliments participating organizations on the air.

A unique feature of this is that the computer matching is performed by the station itself, whereas most other broadcasting stations use an outside source for computer aspects of their matching systems.[11]

Manual Systems - Besides the relatively recent destination-based systems using computers for carpool matching, other destination-based systems based upon manual matching devices have been in operation for at least several years. A recent report to the Federal Highway Administration entitled Manual Carpool Matching Methods, reviewed in the Bibliography of this report, describes several systems.

Most manual matching was based upon some sort of map and card system. Matching was actually done by the participants themselves, in most cases. In other cases, a central office performed the matching function, often in an informal way such as with lists of employees arranged by home town or zip codes.

FHWA considers that such manual systems are adequate for firms with up to 1,000 employees. Manual systems have been used for larger numbers of people, however. For example, Hallmark Card Company used a manual system to match 2,500 of their 4,500 employees. The systems serving the most people are probably those at the Pentagon in Arlington, Virginia (upwards of 25,000 people) and at McDonnell-Douglas in St. Louis (up to 47,000 employees), but it is unlikely that a large fraction of these employees actually used the system. At McDonnell-Douglas, the use of the carpool matching system reportedly provided an average vehicle occupancy of 2.3 when employment was at its peak, but occupancy has declined to 1.8 in the recent past as employment dropped to 25,000.[12] This may show the effect of incentives, inasmuch as the preferential parking provided for carpools at McDonnell-Douglas would obviously be more desirable with a greater amount of competition for parking space.

Destination-Based Carpool Systems in Boston Area - As part of the effort in this study to investigate the WBZ-ALA carpool matching system in Boston (described later in this section), several major employers were contacted to determine their opinion of the WBZ-ALA system. It was discovered that a number of large employers had decided to conduct their own internal carpool matching service either instead of or in addition to encouraging use of the WBZ-ALA regional system.

Several large firms in the Boston area were surveyed and were found to be using a manual or semi-manual matching system, rather than an automated matching system. The firms investigated are using the computer only to generate lists of potential carpool candidates by town of residence, not to actually identify potential matches for a particular person.

Two basic approaches are being used by the Boston area firms which were studied. In one approach, lists of people who have actually expressed an interest in carpools are prepared and either made available on request or distributed to others who are interested. In the other approach, lists of all employees, arranged by home address, are made available for reference by anyone interested in forming a carpool.

It will be useful to discuss several of these employer-based carpool programs as an illustration of what is currently being done without the use of matching computer programs and for comparison with regional matching systems. Five Boston area employer carpool systems were reviewed. Four are operated by companies only for their own employees; the fifth is a joint venture of several companies in one neighborhood. Table 2 summarizes the carpooling characteristic of these five systems.

Company A,* a large manufacturing firm with several plants, used a survey in January 1974 to determine the degree of interest in carpooling among its employees. At present, over 90 percent of the employees come to work by car, and parking is abundant and free of

---

* To preserve the confidential nature of some of these data, companies are referred to in the text and tables only by pseudonyms.

Table 2. CHARACTERISTICS OF SELECTED BOSTON AREA EMPLOYER OPERATED DESTINATION BASED CARPOOL SYSTEMS

Characteristic	Employer Designation				
	Company A	Company B	Company C	Company D	Company Group E
No. of employees	10,000	6,000	2,000	3,000	3,700
Responses to carpool survey	8,000	5,500	--	--	--
No. interested in carpools	2,600	N.A.	N.A.	25%	760
Type of carpool candidate lists	People expressing interest, by zip code, by site.	All employees, by town, by zip code, by work schedule.	All employees, by town.	People expressing interest, by zip code, by shift.	People expressing interest, by town and zip code, by firm.
Lists distributed automatically, or available for reference?	Reference	Reference (other lists in company newspaper).	Reference (other lists in company newspaper).	Distributed	Reference
Parking supplied?	Ample, free.	1100 spaces, paid by employee.	500 spaces, allocated by employer	Ample, free.	Ample, free.
Incentives to carpools	None	None	None	Preferential (closer) parking; contests with prizes.	None
Employee travel characteristics	4% use transit.	40% use transit. 8-10% drive alone. 47% via car. Avg. 2.5 persons/car.	Avg. 1.8 persons/car in company spaces.	26% use transit. 1500 cars in lot, first shift.	No transit service
Effect of carpool service	Unknown	Unknown (not a new service).	Unknown (not a new service).	Cars with passengers increased from 15 to 104. 275 people now in pools. Avg. veh. now has 1.1 persons.	Unknown

charge. Interest in carpooling was expressed by 26 percent of the employees. Lists were generated of the employees who expressed an interest. These lists are arranged by home address zip code; there are separate lists for each employment location. These lists are available from a carpool coordinator at each site (only the list for the particular site is available). No incentives have been provided, but the program has been widely publicized through the company newspaper, bulletin board displays, and special letters from the management to the employees. The WBZ-ALA regional carpool program was also publicized. It is not yet known how many employees have formed carpools, but a follow-up survey is now being planned.

Company B is a non-manufacturing organization with 6000 employees at one site. Carpool information has been distributed in the company newpaper for more than fifteen years. In the recent past this service has been expanded. Notices of carpool vacancies or interest in carpools are exchanged among nearby firms (including company C), with a total employment of over 10,000 people. Notices from all the firms are published in each company newsletter. In addition, a commuter advisor service office has been established which dispenses information and assistance regarding carpools (and transit). This office maintains lists of employees by home address zip code and by work schedule for the use of persons who wish to contact others from the same town or adjacent towns. The WBZ-ALA program has also been publicized and questionnaires were distributed. Recent surveys have shown that nearly half of the employees commute by car and about 40 percent by transit. Parking is available, at a moderate cost, for 1,100 cars in company-owned facilities. Average vehicle occupancy is reportedly about 2.5 persons per automobile, with less than 500 persons driving alone. No explicit incentives are provided for carpooling, but the limited parking space available operates as an incentive. Data are not yet available on whether the amount of carpooling has increased with the recently increased publicity and effort, but additional surveys are planned.

Company C is another non-manufacturer, with approximately 2000 employees at one location. This firm has also carried carpool notices in its company newspaper for several years, and in the winter of 1973-74 expanded this to include reciprocal listings with Company B and a third firm. An administrative office maintains lists of all employees, arranged by hometown, for the use of persons who want to contact others in order to form carpools. The availability of this list has been publicized, and the WBZ-ALA matching service was publicized and the questionnaires were distributed. Parking is provided in a company facility for 500 cars. A survey in the fall of 1973 showed an average of approximately 1.8 persons per car. No explicit incentives are provided, and parking spaces are allocated by company management.

Company D is a manufacturing firm with over 3000 employees at one location, working on a three-shift basis. Ample free parking is available, and an October 1973 survey showed that more than 70 percent of the employees commuted by automobile, and 26 percent via transit. The WBZ-ALA program was not publicized; instead, the October 1973 survey asked people to express their interest in carpools. Approximately 25 percent expressed an interest in carpooling. Lists were prepared of those who expressed an interest (only) and distributed. Each person received a list of other people living in the same zip code area, and people were advised they could also obtain lists for adjacent zip codes or areas on their route to and from work. Preferential parking (i.e., parking substantially nearer the building than most) was instituted for carpools. Substantial publicity was used to encourage carpooling, including contests, prizes, advertising, and special carpool registration periods in the company cafeteria. Only about a dozen carpools existed before the campaign, but by February 1974 there were over 100 carpools with a total of 275 people. Most carpools are among day shift personnel. Average vehicle occupancy is now approximately 1.1 whereas before the carpool program it was barely in excess of 1.0.

Company Group E is a group of firms located in a suburban industrial park area who collectively organized a carpool system. Ten manufacturing and research firms originally discussed participating; so far six have submitted completed questionnaires and been processed. The participating firms have a combined employment of 3,700; of these, 20 percent expressed an interest in carpooling and were processed. The processing consisted of (1) combining the replies from all the participating firms and (2) printing lists of people who expressed an interest in carpooling, arranged by hometown and zip code. The lists were sent to the personnel officers at each firm; there, the lists are available for examination by anyone interested in carpooling. The lists show the employee name, employer name, work schedule, and preferences regarding smoking, ride or drive, and frequency of carpooling. Promotion of this effort varied among the firms but appears to have been modest; ample free parking is available and no incentives have been provided. Matching lists were distributed in mid-March so no data are available concerning the number of carpools formed. Some of the firms had earlier publicized or distributed the WBZ-ALA questionnaire. The area is not served by transit so nearly all employees now commute by car.

There are several common elements in all five of these Boston area destination-based systems. These elements are:

1. The decision was made to not rely upon the WBZ-ALA system. All but one of these firms made the WBZ-ALA questionnaires available but all decided that more effective results could be obtained by in-house efforts. The most commonly voiced reasons for this preference were:

    a. The in-house system would eliminate the problems of disclosing employee data (such as home address and telephone number) to people - strangers - outside the firm. Home addresses were used for matching only by the administrative personnel who already possess this information, and generally only the town or zip code and office telephone are disclosed to potential carpool partners.

b. The in-house, personal approach would be more effective than the anonymous and impersonal WBZ-ALA system. In-house systems would provide face-to-face contact with the administrators of the system and with potential carpool partners.

c. The WBZ-ALA system had not proven to produce productive matches; the matching rate is only 25 percent (see the separate discussion later in this section). Using a home address list allows people to check the lists of other towns or other zip codes within their towns, thus increasing the chance of a match.

2. Matching is performed in an informal, flexible, unsophisticated manner. Using lists of employees by towns or zip codes amounts to customized matching in that each person can use his own criteria for selecting potential partners. Partners can be chosen from nearby locations or from locations on route to work. Little or no computer programming was required.

3. Matching is performed on the basis of hometown or zip codes, not on a grid or other system of home address coding. This system is perhaps more logical in the Boston area than it would be outside of the northeastern U.S., because of the local government structure. In Massachusetts, for example, there is no unincorporated territory; all the state's land area is in organized towns or cities. People identify strongly with their municipality. Furthermore, these towns and cities are fairly small, physically. For example, the Boston Standard Metropolitan Statistical Area, in which most Boston area employees live, had a population in 1970 of 2,730,228 but consisted of 78 municipalities. In effect this means that even in a large firm there would not be an awkwardly long list of employees for any one community, except perhaps for Boston and one or two other nearby cities. Most of these larger communities are, however, well served by mass transit so carpooling interest is small. Furthermore addresses in the larger communities can be sorted by zip codes. The zip codes generally follow neighborhood demarcations in these larger communities and are thus perhaps more logical for coding addresses

than they would be elsewhere. In addition, it should be noted that there is a one-to-one relationship between zip codes and municipalities. Each city or town is uniquely identified by a zip code. There are only nine larger communities with multiple zip codes in the Boston area. This observation will be important when the WBZ-ALA program is discussed. Thus, sorting by zip code or hometown produces matching lists with reasonable numbers of names.

4. Where surveys have been taken among these firms, only a minority (roughly one-fourth) of the employees have expressed an interest in carpools.

5. With one exception, firms have provided no explicit incentives for their employees to form carpools.

6. Vehicle occupancy is measurably higher where parking space is restricted in availability or not provided free.

7. Firms A, B, C, and D all are now or have been involved with other commuter assistance functions. All had been informally providing carpool information, or providing information on transit service. Two firms have also organized inter-plant company shuttle bus service as a result of the same economic forces which have encouraged carpools. Also, all have initiated carpool efforts in recognition of the requirement in the Boston area Transportation Control Plan that major employers must reduce their automobile parking space supply by 25 percent in the near future; some of these firms explicitly expect to accomplish this through their carpool programs.

8. Companies A, B, C, and D all have extensively publicized their carpool programs, and all but Company D also publicized the WBZ-ALA program.

It is reasonable to conclude that these Boston area carpool systems are all operating successfully in the sense that they are apparently able to cope with the present demand for carpooling information. All provide information systems which are flexible and readily available. But it is not possible to conclude that these systems could provide enough matching information if most people in such large firms simultaneously wanted carpool information, if gasoline should suddenly become less available or when the mandated parking space supply reductions become a reality. Furthermore, it is not clear whether the overall company carpool campaigns by themselves are adequate to encourage large-scale carpooling. What is clear is that both preferential treatment of carpools (as at Company D) and restricted parking supply (as at Company B and to a lesser extent at Company C) can substantially increase vehicle occupancy above the urban average, even without elaborate carpool matching systems, at least among employees of larger firms.

Summary of Experience with Destination-Based Systems

Systems designed to facilitate the formation of carpools among employees working at one location have been in use for many years. In the recent past the need for carpool matching systems has increased, because of declining transit service, dispersal of employment throughout metropolitan areas, and because of the rapidly rising costs and problems associated with automobile travel. The destination-based carpool matching systems have simultaneously become more sophisticated, using computers to perform the matching function. Experience with several modern matching systems shows they can be effective if combined with suitable promotion and incentives.

Experience in the Boston area suggests that relatively simple, customized destination-based carpool matching can still provide effective matching services even for large numbers of employees (up to a few thousand at one location). But experience has not yet shown whether such systems can cope with the amount of carpool matching needed to substantially reduce vehicle use by commuters. Nonetheless, experience with selected firms shows the potential for increased vehicle occupancy if incentives and adequate matching services are both provided.

EXPERIENCE WITH REGIONAL SYSTEMS

General

Systems to match potential carpool partners throughout a metropolitan region are relatively new. The concept is to establish an information system to identify people who (1) live near one another, (2) work near one another, and (3) work similar schedules.

The potential advantage of regional matching is that it can provide more people with potential carpool partners than destination-based systems usually can. For example, two people who live near each other and work near each other would never be matched if they worked for two firms with individual destination-based carpool matching systems. This is particularly important for employees of small firms and residents distant from their work place; such people have low probability of matches on destination-based systems. Furthermore, regional systems can provide everyone equal opportunity to participate in a matching system, regardless of whether his employer provides carpool matching services. In theory, a regional system could provide the same number of matches to employees of large firms as would a destination-based system, if the same people participate, because the data base would be the same. And in theory, the regional system could provide much better service to employees of small firms than would a destination-based system, because the data base would be larger and the chances of matching would be higher.

The operation of such a system involves several functional steps (leaving aside for the moment such administrative aspects as promotion and incentives):

1. Collection of data on the home address, work location, and work schedule for each potential carpool candidate. Data on personal preferences, such as smoking, may also be collected.

2. Translating the home addresses and work locations into a consistent code with which the computer can operate in order to match the candidates. This step is referred to in some literature as geo-coding. Home addresses are usually coded according to town, zip code, or location on a grid numbering scheme on a map of the area. Work locations are usually coded according to either a grid numbering system or a list of specific locations or landmarks.

3. Matching the carpool candidates. The computer sorts the data to identify people who (1) work in the same coded area, (2) live in the same coded area, and (3) work the same schedule. Some systems provide for the computer to also match people who live in adjacent coded areas, work in adjacent areas, or work slightly different hours. In addition, candidates may be further sorted according to personal preferences (such as smoking). Systems must deal not only with original matches but changes after the system is used for a while, as a result of address and employment changes.

4. Distribution of lists of the potential matches to each of the carpool candidates.

In performing the above steps, systems can differ from each other in many ways. The data collected varies; some systems ask many questions, others ask only a few. The geo-coding can vary; many forms of map grids and other coding systems can be used. The matching process can vary; systems vary in the criteria and methods for matching. And distribution varies; systems differ in the manner of distribution and in the kind and amount of data distributed. Hence there is a great variety of possible systems for performing regional matches.

Regional carpool matching systems can also involve employees directly. All but the third functional step - the actual matching process - can be done entirely within the employer organizations rather than through a public medium. What distinguishes regional systems is that the matching is done on a regional basis. Hence, employers could collect data, publicize the program, and distribute the output, while at the same time all the data from a region is actually pooled together.

In the face of all this potential variety in operation, however, there is only a limited amount of experience. Regional carpool campaigns are all less than one year old, and none has matched more than 10,000 to 15,000 candidates. There has therefore been little opportunity to thoroughly examine the results of the many regional systems in operation. This report will review the experience with some of the regional systems which have been in operation the longest. Besides the pragmatic approach of examining experience in this section, Section IX will examine some theoretical aspects of such systems.

Case Histories of Regional Systems

General - This report will review the current information on a few regional carpool matching systems. Again, the emphasis will be on highlights, recent developments, and contrasts with other kinds of systems. Additional case history material is available in the literature published by the Federal Highway Administration and described in the Bibliography of this report.

WBZ-ALA, Boston - Station WBZ is a major AM and FM radio and television broadcasting outlet in Boston, operated by Westinghouse Broadcasting Company. In the past several years WBZ has conducted several major public service campaigns. For example, in 1970 the station conducted an anti-smoking effort; in 1972, several special programs and related public service functions were devoted to drug abuse education and control; in the summer of 1972 a physical fitness campaign was conducted. These campaigns have been characterized by intensive publicity, special programming on the air, and community involvement through such techniques as WBZ's provision of a physical fitness course on Boston Common.

In September 1971, WBZ joined forces with a Boston-based automobile club, the ALA Auto and Travel Club, to operate a free towing and assistance service on the major commuter road into Boston from the south (the Southeast Expressway). This is coupled with traffic surveillance by a WBZ helicopter, and both have continued through the present time.

WBZ continued its transportation public affairs involvement in the summer of 1973 by introducing the "Commuter Computer Clubcar" carpool matching service, again in conjunction with the ALA Auto and Travel Club, which is the oldest of several broadcaster-operated regional carpool systems.

History of the carpool campaign - The WBZ-ALA carpool campaign was announced in August 1973. The system details were described, and audience response requested, in a special 90-minute television program in prime time. The matching system was intensely advertised on the air, in other media, and through industrial groups and the Chamber of Commerce. By March 1973, approximately 15,000 applications for matching had been received. The rate at which applications have arrived has varied, with a higher rate of applications during periods of heavy promotion and during the periods of long queues for gasoline.* Applications are continuing to arrive at the rate of a few hundred per week.

Organization - WBZ carries most of the burden for publicity and coordination. The ALA Auto and Travel Club provides the computer matching service, some promotional expenses, mailing costs, and all clerical effort. WBZ and ALA have also enlisted the assistance and endorsement of the Associated Industries of Massachusetts, the Chamber of Commerce, several major employers, and the government transportation agencies.

---

*Gasoline shortages in the Boston area resulted in 1- to 2-hour queues for gasoline in much of February 1974. In addition, the collapse and subsequent repair of a major toll bridge in September 1973 provided another incentive for carpools.

Publicity and data collection - Promotion of the Commuter Computer system began in August with public service announcements and editorials on WBZ radio and television. The Massachusetts Secretary of Transportation endorsed the system in a press conference on 23 August, and major newspaper coverage resulted. On Friday, 7 September, WBZ staged a "Great Commuter Computer Clubcar Race," in which WBZ personalities and government officials used distinctive automobiles (such as antique cars) and "raced" into Boston to dramatize the frustrations of traffic and the potential for carpools. That evening WBZ carried a 90-minute special on television, with government officials (including the Governor) discussing transportation issues and Westinghouse personalities operating a telephone service for commuter computer applications, much in the style of a charity telethon. WBZ continued to heavily promote the carpool system, through radio and television announcements (at least twice an hour), press conferences, and advertisements in local newspapers and on billboards. Besides offering questionnaires to the broadcasting audience, they were distributed in bulk to large employers, to central distribution points such as supermarkets, and given out by toll collectors at the Boston tunnels, turnpike, and toll bridge. The system was publicized to employers by industry and commerce organizations, and by employers in their own house organs. Over 500,000 questionnaires have been distributed. In addition the questionnaire was printed in all the major Boston and suburban newspapers in September (but few responses used those forms). Articles about the campaign have been carried by several local and national newspapers and magazines, as well as in national broadcast news. In the past month or two the amount of publicity has been reduced to a few spot announcements per day on the air, but applications continue because of the gasoline shortages. The public is asked to mail questionnaires to WBZ, along with ten cents for postage.

Incentives - Few explicit incentives have been provided. The thrust of the WBZ campaign has been to overcome public antipathy to carpooling, make it socially acceptable, and to make it fun. Originally it was planned that members of the "WBZ Commuter Computer Clubcar" would obtain promotional benefits such as free coffee from roadside restaurants, but to date these plans have not come to fruition. One inducement has been a contest in which an automobile was given away to a carpool applicant. This resulted in an increase in applicants but apparently also resulted in many duplicate applications. A coincidental incentive was the opening of an express lane for carpools and buses on Interstate 93 leading into Boston from the north.

Matching process - ALA processes the applications on its own computer. Matching is based on (1) home zip code, (2) place of work, (3) hours of work, and (4) other preferences. Applicants are matched only with other people with the same home address zip code. Destinations are coded according to a list of approximately 60 landmarks in the Boston Metropolitan area. (Only 36 landmarks are listed on the questionnaire; the others have evolved from processing the applications. A blank category for additional locations is provided on the form.) Work destinations include major employment centers ("Government Center/ City Hall"), specific sections of downtown Boston ("Park Square"), suburban employment areas ("Dedham/128 Industrial Parks"), and park-and-ride locations for mass transit service ("Riverside Station"). Work hours can be separately identified by starting time, quitting time, and whether occasional rides are needed for departures one hour later than usual. One can indicate preferences for drive, ride, alternate driving; and either male or female companions. An additional feature is an option to indicate a desire for rides to major sporting events.

The matching program is run on an IBM 360/20 computer with an 8K core and a card system for input. For approximately 10,000 names in the data base and three or four weeks of applications (several hundred), it requires about 9 hours to do an entire processing cycle, including preparation, sorting, elimination of duplicates, and preparing letters. About two hours of actual computer time is involved for a typical run. With a tape or disc system, ALA believes the time could be reduced substantially.

The computer matching results in a letter print-out for each new applicant, indicating his potential carpool matches or stating that no match can be made. The computer printout itself is suitable for mailing. When matches are made, the list sent out is accompanied by a package with literature on carpools, special "Commuter Computer Clubcar" membership cards and window decals, highway and transit system maps, and an accident check list. The matching process is re-run every three or four weeks. Only new applicants receive printouts, but all applicants are retained in the data bank.

Employer participation - Several major and many smaller employers, including government agencies, distributed questionnaires for the WBZ-ALA system. Associated Industries of Massachusetts offered a service in which they provided WBZ-ALA questionnaires with a firm's own message and company insignia printed on the form. Few employers collected the forms themselves, so it is not known how many of the completed forms resulted from this process.

Results to date - By mid-March 1974, the total number of applications received was 15,000. After separating duplicates and applications which cannot be processed, the data base in the computer was 11,141. Of these applicants, 25 percent (approximately 2,800) were matched to at least one other applicant. The rate at which matches are made has been steadily rising as the number of applicants increases. (Also see Section IX for further analysis of these results.) Both WBZ and ALA are disappointed that more applications have not been received and that the matching process does not produce more matches, but WBZ and ALA will continue the program at least through August 1974. (Matching rates should be interpreted cautiously; see discussion on page 68.)

As was pointed out in Section I, the WBZ-ALA carpool system has been made an official part of the Transportation Control Plan for the Boston Air Quality Control Region, and the promulgated regulations specify that the Commonwealth of Massachusetts must operate a replacement system if WBZ and ALA cease their operation. Plans have not been completed, but the Massachusetts Executive Office of Transportation and Construction is working with FHWA, WBZ, ALA, and major employers to devise an expanded and improved system to replace the ALA-WBZ system. According to discussions with the officials involved, the state may work with large employers to provide destination-based matching for them, and would also provide a regional matching system. WBZ and ALA may continue to be involved. No decision to proceed with planning the details of such a replacement system has been announced, nor has WBZ or ALA altered their commitment to complete their one-year campaign.[13,14,15]

WIND, Chicago - WIND is an A.M. radio station in Chicago, operated by Westinghouse Broadcasting Company. Station WIND has been conducting a regional carpool matching campaign similar in several respects to the WBZ-ALA campaign described earlier. WIND (and the other Westinghouse (Group W) stations) was assisted by WBZ in organizing their campaign.

There are, however, some important differences between the WBZ-ALA campaign in Boston and the WIND campaign in Chicago. For one, WIND is actually conducting both a region-wide campaign, in which the general public is solicited to submit applications, and destination-based matching for specific employers. Because of the small number of employers involved so far, the WIND campaign will be treated as a regional carpool system for the purposes of this discussion.

Another difference between the WBZ-ALA system and the WIND system is that the WBZ-ALA campaign is the only broadcaster-operated campaign (and the only regional campaign) in Boston, whereas a second Chicago radio station (WBBM) is operating a carpool matching system. The WBBM system is described in another portion of this section (page 17).

A third difference is that the WIND computer matching is done by a private firm, Automatic Data Processing, using a different program from the WBZ-ALA program. The matching program will be further discussed below and in Section IV.

History - The WIND system has been operated in a manner similar to the WBZ-ALA system, but with a slightly later start. The station carried editorials throughout 1973 dealing with several aspects of transportation. In an editorial on September 6 and 7, 1973, WIND discussed the need for a "commuter computer", not specifically in connection with carpools but rather on a more general basis in connection with analyzing Chicago's transportation needs. Then on October 11 WIND announced the official beginning of the "Commuter Computer" carpool matching service. Publicity of the system was coupled with publicity for other WIND transportation-related programs. On November 5, a "Great WIND Chicago Commuter Race" was held to publicize the city's traffic problems and dramatize the potential for carpools. (WBZ staged a similar race in Boston.) Publicity and data collection has continued to the present time, and a one-year campaign is planned.

Publicity and data collection - In addition to the "Great Race" and the editorials previously mentioned, the carpool system has been promoted over the air, through press releases to other media, and in newspaper advertisements. Applications are available to people who either write or call the station; people who write for an application are asked to send a stamped, self-addressed envelope. Applications have also been delivered in bulk (approximately 150,000 so far) to major employers and other mass distribution points. Employers have distributed a large portion of the applications so far, and have either collected them or asked employees to send in their own. The application form is quite simple, with only four questions - name, address, phone number, and location of work; arrival time; departure time; and preference of drive or ride. Destinations are identified by numbered grid squares on a map on the questionnaire.

Matching process - The matching program was prepared by the data processor, Automatic Data Processing, Inc. (ADP), which is serving other Westinghouse Broadcasting Company stations with the same program. The program matches applicants on (1) home address zip code, (2) destination grid number, and (3) work times and drive/ride preference. The program does not search adjacent home zones for additional matches but does search adjacent work zones. The program is written in COBOL and versions have been written for both Honewell and IBM machines. As with the WBZ-ALA program, the WIND-ADP program keeps all applicants to date in the file, and sends letters with output only to new applicants. (Also see Section IV.) Some firms are performing their own keypunching; otherwise ADP is performing all the data processing for both the regional and destination-based matching.

Employer participation - Employers are provided the option to either pool their data with the region-wide applicants or to keep them separate. Employers distribute, publicize, and collect questionnaires within their firms.

Results to date - By mid-March 1974 approximately 3500 applications had been received from the general public and new applications were arriving at the rate of about 100 per week. Between 10 and 20 percent of applications are being matched. Employer responses are just beginning and consequently no data are available.[16,17]

Other Westinghouse Broadcasting Company Stations - Several other Westinghouse Broadcasting Company (Group W) radio or television stations are conducting, or participating in, carpool matching systems. These campaigns are in most cases based upon the WBZ-ALA campaign, and several use the ADP computer program. Several of these will be summarized here.

KDKA, Pittsburgh - The KDKA "Commuter Computer" campaign began in October, and was publicized in a manner similar to the WBZ-ALA and WIND campaigns. Over 200,000 application forms were distributed, about 5000 were received, and approximately 500 carpool matches resulted. Computer processing was done by ADP. The campaign is now going to be combined with that of the Southwestern Pennsylvania Regional Planning Commission (SPRPC), which is initiating a regional carpool program to be funded by FHWA. The 5000 applicants to KDKA's campaign will be sent new applications for the new SPRPC system. An entirely new computer program, reportedly similar to one developed by the U.S. Bureau of the Census, is now being tested. KDKA will continue to be involved in the promotional aspects of the new campaign.[18]

KYW, Philadelphia - The KYW campaign was structured after the WBZ-ALA campaign, but began only in February, 1974. Approximately 1000 applications have been received and processed, but no matches resulted. The matching process uses zip codes for home address matching, with large zip code areas further divided into townships or boroughs in some cases. Destination matching is by landmark or general area, as in the WBZ-ALA system, not by grid or zone. Data processing and clerical aid is provided by the Keystone Auto Club. Processing is done by a custom program, written in COBOL for an IBM 360/40. The program requires 15 minutes for 1000 applicants and uses 75K bytes of core.[19]

KPIX-TV, San Francisco - Several business and several government agencies in the San Francisco Bay area have joined together to form a carpool organization which is conducting a region-wide matching campaign, called "RIDES". Overall coordination is the responsibility of a steering committee which represents the business sponsors and the governments; an official from the FHWA regional office acts as chairman of the committee. The role of KPIX-TV has been promotion; another station, KSAN, is also involved. Other promotional and printing expenses are borne by the private sector. The Association of Bay Area Governments (ABAG) is performing the geo-coding, using a computerized technique based upon the U.S. Census Bureau DIME files (discussed elsewhere in this report). Destinations are coded landmarks or areas, as in Boston and Philadelphia. Actual matching is being done by the California Department of Transportation on a modified version of the U.S. Census carpool matching program. This program searches for additional matches in zones adjacent to the home zone. So far, approximately 25,000 applications have been received. (The large number of applications results from the large population in the area being served, and a lengthy gasoline shortage.) Of these, about 15,000 were processed in late March and an 84 percent matching rate resulted.[20] (See also Section IV.)

WJZ-TV, Baltimore - The Baltimore carpool system is being operated by WJZ-TV, WFBR Radio, and the Automobile Club of Maryland. Matching is performed with an Automobile Club computer program, based upon a grid system for origins and destinations. The system has been promoted on the air by both the broadcasting stations. Questionnaires were also distributed through all McDonald's restaurants in the area and through major employers. So far (after 4 months of operation), approximately 2000 questionnaires have been returned. No data processing for matches had been performed as of the end of March, 1974.[21]

Summary of Experience with Regional Matching Systems

Several systems designed to provide carpool matching services throughout a metropolitan region have been placed in operation within the past year. In all of these systems, radio or television broadcasters have been involved and in several cases have been the chief supporter of the system. Most such systems are being operated by commercial enterprises as a public service, but in at least one system

(San Francisco), a government agency (the California Transportation Department) is also supplying technical effort.

The system in operation the longest, the WBZ-ALA carpool system in Boston, has attracted and processed only 15,000 applications from a metropolitan area population of more than 2.5 million people. The system with the most applications to date is the San Francisco system, which has been in full operation less than two months but has attracted approximately 25,000 to 30,000 applications from a metropolitan area population of more than 3.0 million people. In Boston the matching rate is 25 percent, in San Francisco it is 84 percent among the first 15,000 applicants (but note the matching programs are quite different).

Regional systems in operation at the present time have been accompanied by extensive promotion but few explicitly-provided incentives. In no city has a follow-up study been done to determine how many carpools are formed either directly from the matching lists or indirectly as a result of the promotion of the carpool concept.

One outgrowth of regional systems for carpool matching has been the development of systems which combine the features of regional and destination-based carpool matching systems. Such combination systems will be discussed next.

EXPERIENCE WITH COMBINATION SYSTEMS

General

Combinations of destination-based and regional carpool systems have evolved from the recent efforts to provide matching services to an entire metropolitan area. Although the history of these systems was not exhaustively researched for this report, discussions with the principals in several carpool systems indicate that the combination, or dual, approach probably grew out of the twin desire to serve a wide area and also to capitalize on the high potential for destination-based systems, and thus avoid the disappointing response to the WBZ-ALA system and other early regional carpool systems.

The typical combination system involves the solicitation of applications for carpool matching from both the general public and from employees indirectly through their employers. Some systems actually maintain a separate data base for the general public from the employer data bases, so such systems are actually multiple carpool matching systems being operated simultaneously. In other cases the employer data are combined with the general public data. So combination systems can be based upon either destination-based matching systems or regional matching systems.

It appears that most publicly-operated systems now being begun in the U.S. are combination systems of some sort. Few regional systems are being operated without overt attempts to work through employers as well as to appeal to the general public.

Case Histories of Combination Systems

General - As with the other case histories for regional and destination-based systems, the emphasis in this section will be on highlights, recent developments, and comparisons with other systems. Most of the systems to be discussed here have also been reviewed in the recent reports published by FHWA and referred to in the Bibliography.

Denver, Colorado - The carpool matching system being operated in the Denver, Colorado, metropolitan area appears to be unique in several respects. The system has evolved from the work of a computer class at George Washington High School, rather than from an overt attempt by a government agency or broadcaster to create such a system. Furthermore, the computer program itself was written largely by high school students and is somewhat different in its matching logic from any other program reviewed for this report. At the present time the system is evolving from a destination-based system into a combination system, and responsibility for it is being transferred from the high school to local civic organizations. Eventually it is planned that a government agency will coordinate the system.

History - Unlike most carpool matching computer programs, which were created to satisfy a demand, the Denver matching computer program began as a class exercise in the computer math class at George Washington High School. Some employers had been operating a carpool system before this, but with small and declining interest.[9] When the computer program was operational it received publicity from an article in a Denver newspaper and from news items on Denver area radio and television stations. As a result of this publicity, several local businesses and government agencies made inquiries about the program. The students and their teacher, Dr. Irwin Hoffman, began to make presentations to interested groups, and several employers have adopted the program.

Interest in the computer program has grown to the point that the school cannot handle all the requests for assistance nor can it do as much data processing as would be required to satisfy the demand. Consequently an organization consisting of local civic groups and the regional council of governments has been established in order to take over the operation and expand it further. At the present time the organizations are trying to obtain Federal and State financial support in order to carry out the regional aspect of the system. Most of the work done to date and in process has involved matching on an employer-by-employer basis.

Organization - Initially, George Washington High School staff and students handled most of the effort. The organization at present is being coordinated by Downtown Denver, Inc. (DDI), a membership group of Denver business. The Rocky Mountain AAA Auto Club (AAA), a local affiliate of the American Automobile Association, is assisting with publicity, employer contact, and clerical and keypunching work for some employers. Generally, DDI is responsible for the contacts with downtown firms and AAA is responsible for employers outside the downtown area. A local computer service company, Min-Comp Computer Corp., has agreed to do the data processing for firms who do not wish to do their own, and for the regional matching when it is begun, at a fixed price per person. The entire software package - the computer programs, personal instructions in its use, and instructions on geo-coding and other functions - is being offered to any organization at no charge. The George Washington High School staff and students are still involved in altering the basic programs to suit the particular needs of participating organizations. Several government agencies have endorsed the program and participate in it, and the Region VIII office of EPA has presented an award to the high school for their efforts, but otherwise no government agencies are yet strongly involved. Attempts are now underway to obtain funds from the FHWA for the Denver regional Council of Governments to carry out the bulk of the work to widely promulgate the system and establish the regional data base. State funds have been obtained for DDI to operate the system from April until the FHWA funds are obtained.

Publicity and data collection - At the present time the system is largely a family of destination-based systems and as a result most of the promotion has been directed at employers. Within participating employers, the companies themselves have handled publicity and data gathering. Promotion to the employers has thus far been handled by DDI and AAA, as noted earlier.

With the destination-based system, a questionnaire is filled out for each employee, either by himself or by a staff member who has access to the required information. Next, the employee's home address is converted to a digital code (that is, it is geo-coded) by a clerk.

The data are then keypunched onto computer cards, either by the employer or by AAA. The collected cards for one company are then run through the matching process, either on the employer's computer, at Min-Comp, or at the high school. The output is then either returned to the employee through company channels or mailed to his home; the computer output can be folded and used directly as a mailer.

Matching process - The software for matching is a family of three computer programs, plus a process of geo-coding. One program creates initial carpool listings for a data base. A second program updates the listings to provide new printouts for added people, people who have moved or changed jobs, or corrections. The third program produces a density matrix to show the distribution of potential carpoolers (or transit riders) by geographical location.

The matching process itself appears to be unique. Rather than operating with grid cells or origin-destination designations, the program uses actual x/y coordinates of homes and destinations. This enables the use of a unique vectoring method for locating carpool partners convenient to the candidate's route from home to work. This matching program will be described in greater detail in Section IV.

Results to date - Several major employers have reported substantial changes in driving habits as a result of the carpool system. Great Western Sugar Company reported that 25 to 35 percent of their 250 employees are now carpooling, whereas few did previously. The Air Force Accounting and Finance Center surveyed their 3,400 employees in December and found about 25 percent were already in carpools. Of the 86.9 percent of the employees who returned the survey forms, 1,424 expressed an interest in carpool matching and were processed. By February 1974, the number of people using carpools had risen to 1,547 (over 45 percent) (and 288 people were using public transit). Altogether approximately 10,000 employees have been processed by one of the firms with the program. Typically, 99 percent of employees have received at least one potential match.[22,23]

Dallas, Texas - The cities of Fort Worth and Dallas have coordinated in a single carpool matching system in which employers and the general public are being requested to participate. Again, however, the emphasis at first is on obtaining cooperation from major employers.

History - In October 1973 a pilot project was undertaken to perform computer matching for 650 Dallas city employees. The next step was to extend the data collection to other city employees. In December 1973 and January 1974 a series of meetings was held in which employers (private and government) were briefed on the carpool system and invited to participate. In selecting employers to attend these meetings the city used a Chamber of Commerce tabulation of the number of employees in each firm; the city attempted to first reach major employers. So far representatives of employers with a total of more than 100,000 employees have been given a presentation. By early March, 1974, approximately 35 percent of Dallas employers had completed the data collection phase, and data collection was continuing. Dallas has submitted an application to FHWA for a grant to conduct this carpool program over the next two years. If the grant is approved it is intended to attempt to process all the employees in Dallas County.

Organization - Overall coordination has been the responsibility of the Traffic Control Departments of the two cities. The Chamber of Commerce assisted in promotion and contacting employers. Two broadcasting stations are conducting their own compaigns but efforts are being made to coordinate them with the city campaign. Employers asked to participate are requested to appoint a coordinator to be responsible for the effort within the firm. Employers are asked to obtain maps and survey forms, distribute these to their employees, and then collect them when completed. Employers were given the option of either processing their own data or having the city perform this. Keypunching can be done either by the city or the employer, as can data processing. The intention is to eventually process the entire region, so employers are encouraged to pool their data together.

Matching process - The FHWA computer matching program is being used in the Dallas-Fort Worth program. With that program, the matching is based upon a grid system for both origins and destinations (i.e., home and work addresses). The grid system being used is a single system of rectangular grids for the two-city metropolitan area.

Results to date - The City of Dallas reported in early March that not enough data had been processed to permit evaluation of the matching process. As noted above, approximately 35 percent of the employers have submitted their questionnaires.[24, 25]

Connecticut Cities - The Connecticut Department of Transportation has been involved with programs to encourage or support carpool use for several years. Recently these efforts have included provision of carpool matching services for private employers and for regional systems.

History - In 1969 the Connecticut Department of Transportation (ConnDOT) determined from a survey that a substantial number of people were parking their cars at highway interchanges - often in an illegal or dangerous location - in order to join carpools.[26] This led ConnDOT to begin a program of constructing commuter carpool parking lots at highway interchanges throughout the state. By late 1973 the state had built 11 such lots and 13 are scheduled for completion in 1974. In addition, 79 emergency (non-permanent) lots are planned for interim use during the present fuel shortage and until permanent lots can be designed and constructed.

In parallel with the development of the carpool parking lots, since June 1973 ConnDOT has provided computer carpool matching services to several parts of the state. The matching service has been used in both destination-based, employer-operated systems and regional systems.

Organization - Several organizational structures are in use. Government agencies, including ConnDOT, and other employers have been provided the carpool matching data processing service, with actual administration performed by the employer involved. These carpool operations have been destination-based matching. In addition, regional carpool matching services have been developed in several cities. In Hartford, the sponsors are ALA Auto and Travel Club, a major bank, the Insurance Association of Connecticut, and an AM-FM radio station. In Newington, the sponsors are an AM radio station, an insurance firm, and a bank. The southeastern Connecticut (Norwich area) system is sponsored by a consortium of local industries and government agencies. The New Haven system is sponsored by AAA and a local radio station. In each of these cities, the data are collected by the local sponsors, on standardized application forms with local sponsors identified, and processed by ConnDOT on a regional basis.

Matching process - ConnDOT has written its own matching program. Geographic matching is based on Connecticut's 1,725 traffic zones, which vary in size according to population density and land use. Consequently, each application must be hand-coded to identify the traffic zone corresponding to the applicant's address. Besides address and work schedule, the program matches applicants on their preference to drive or ride. The program is written in FORTRAN and run on a UNIVAC 1106 computer, but is not documented.

Results to date - By January 1974, matching services had been provided to 50,000 employees of 20 firms. In Hartford, the program provided matches for two-thirds of the first 2,500 applicants. Data collection and promotion are continuing, with area-wide systems operating in all the major urban centers in Connecticut.[27]

Washington, D.C. - The Metropolitan Washington Council of Governments (COG) has coordinated the efforts of several government agencies to do destination-based matching throughout the metropolitan region.

History - The COG program was announced in September 1973, after planning for several months. The Northern Virginia Transportation Commission (NVTC), one of the cooperating agencies, started a pilot matching campaign at an industrial park in Virginia in September. The COG computer program was actually developed for the NVTC operation. Promotion and use of the system is still being expanded.

Organization - The carpool system is at present being operated through employers. COG has worked with the Metropolitan Washington Board of Trade, the Federal City Council, and other business organizations to promote and encourage use of carpool matching and carpool incentives. A special transportation committee, representing business and government sectors for several years, has endorsed and is working to promote the COG system. WTOP, a Washington radio and television station, also participates in the promotion of the campaign, and supplies questionnaires.

Matching process - Actual computer matching is done by COG using a program they prepared. Home address matching uses the Census Bureau DIME files for geo-coding. Destinations are treated one at a time but the program is reportedly capable of use in multiple destination systems. (It is planned to solicit responses from the general public at a later date.) The program was written in COBOL for an IBM 370/158 and requires a large amount of core (100K). Documentation was not complete by mid-March, 1974.

Results to date - By mid-March, approximately 35,000 questionnaires had been completed, for several destinations. Matches are provided for 80 to 90 percent of these applicants.[28,29]

Knoxville, Tennessee - The carpool matching system in Knoxville, Tennessee, is another example (like Denver) of a system in which destination-based matching forms the nucleus for the system, with a planned expansion to regional matching in the future. In the Knoxville system the city government has been heavily involved, which is unusual, and there is an emphasis on using the survey data for transit planning, which is also unusual in practice if not in concept.

History - Planning for the "Car-Bus Pool" began in early 1973, largely as a technique to improve transit planning and operation. Publicity and detailed planning continued through the winter of 1973-1974, and survey forms were distributed in February 1974. Survey forms are currently being processed. Some changes to the transit routes have already been made, and park-and-ride facilities are being initiated. A Knoxville radio station which originally attempted to organize a separate, WBZ-type system has now turned over their data to the city and combined efforts with the city.

Organization - The organization of the Knoxville system is a unique combination of public and private forces. This organization is discussed in detail in the literature,[9] so it will only be summarized here. The chairman of the carpool/buspool program is a member of the Knoxville Transit Authority, in keeping with the philosophy that carpools are a portion of the mass transit system. A planning committee is composed of representatives from both private and public sectors. An appointed advisory committee represents the community, and technical staff is provided by the University of Tennessee and the regional planning agency. In addition, the mayor assigned a special assistant as a transportation coordinator.

Major employers have been heavily involved. Knoxville has several large, relatively separated employers who account for much of the workforce, so destination-based matching was deemed to be appropriate for most employees. Bus routes have been tailored for specific major employers, and employers have distributed and collected the carpool/buspool survey forms. All the media - newspaper, radio, television, and billboards - have been used for promotion. The Mayor has personally given public support and the survey forms begin with a letter from the major. The Chamber of Commerce is assisting by distributing survey forms to employers.

Matching process - The University of Tennessee has extensively revised the FHWA matching program for use in the Knoxville system. Matching uses the origin grid cell, destination, and work schedules, and in addition uses an array of personal preference questions designed to produce matches which are personally compatible as well as convenient. The program is being run on an IBM 360/65 computer. Program modifications are continuing to be developed, and it is planned to incorporate a matching search on the destination end.

Results to date - Approximately 65,000 questionnaires have been distributed to employees of 360 firms in February and March 1974, and approximately 20,000 have been completed and returned. Of those returned, approximately 65 percent have expressed an interest in carpool/buspool matching services.[9,30]

California Cities - The California Department of Transportation (CalTrans) is organizing a carpool system for use in cities throughout the states (except in San Francisco, where the system described elsewhere had already been organized). The CalTrans participation includes the matching service, promotion, research, planning incentives, and advice on non-technical aspects such as law.

History - CalTrans began in early 1973 to prepare a carpool matching program. In October 1973 the Governor asked for the establishment of voluntary carpooling as an energy-saving technique. In December 1973 the Governor assigned CalTrans the responsibility of assisting in the development of carpool systems for all state agencies. Also, the District Directors of Transportation were assigned to coordinate and assist local carpool efforts. Formal organization plans for the state headquarters effort were complete by February 1974, and detailed planning and implementation of systems are now underway.

Organization - Within the state government, a Supervising Highway Engineer has been assigned as Car Pool Coordinator by CalTrans. Assisting him is a team from the CalTrans staff, representing services including public information, computer services, finance, legal, supply, and engineering. Other headquarters staff operate the computer matching systems, carry out research, prepare publications, and provide coordination with the regional offices of CalTrans. Regional Coordinators have been assigned, with responsibilities for promotion, liaison, consulting, and coordination with employers. CalTrans is making available their matching service and consulting services to other State agencies, and plans to offer these services to the private sector as well. State involvement will include publicity and providing incentives, also.

Matching process - The FHWA matching program is being used (except in San Francisco, where the modified Census Bureau program is being used). Eventually CalTrans hopes to operate two parallel matching services, one for destination-based matching and one for regional matching. In the beginning, however, the emphasis is on a campaign to perform destination-based matching for one organization at a time. This stems from CalTrans' conviction that people strongly prefer to carpool with others from the same employer. The regional system would involve a telephone advisory service which could assist individuals not matched through employer groups. The staff for this service would have the master output from the destination-based system and would provide a broker-like service to match the isolated individuals with other carpools. In addition a computer program is planned to provide custom matching service if the organization-based output is not sufficient.

Results to date - The statewide campaign is fairly new so few results have been reported. In an initial campaign at CalTrans headquarters in

Sacramento, 1700 out of 2000 employees returned completed survey forms. Preferential parking for carpools was instituted and the number of carpools increased from 90 to 150.

Incentives - CalTrans emphasizes the importance of incentives. Within CalTrans, incentives for carpooling include preferential parking and flexible work hours in order to facilitate use of carpools (or of transit). Other incentives are being studied.[31,32,33]

Summary of Experience with Combination Systems

Combination carpool matching systems incorporate some of the features of destination-based matching systems and some of the features of regional systems. Combination systems attempt to serve a metropolitan area but emphasize strong employer participation in order to achieve a large data base. Some combination systems are operated by the private sector but the trend appears to be for government to organize such systems.

Combination systems are relatively new, so it is difficult to conclusively show their effectiveness. Nonetheless, the systems reviewed for this report show great promise as mechanisms for both encouraging carpooling and providing the matching service needed to facilitate the formation of carpools.

The most successful combination systems (Denver and Knoxville, e.g.) are characterized by enthusiastic support from a broad-based coalition of government officials, business leaders, and major employers. Such systems also tend to have the most highly developed computer matching programs, but this may be a result of their recent beginnings rather than a key to the success of the system. Operators of the combination systems believe that the key to their service is the dual approach of (1) providing destination-based matching to large concentrations of employment and (2) later expanding to a regional data base to assist the minority of employees not reached through major employers.

Of the systems in use and reviewed for this report, the Connecticut and Denver systems have the greatest amount of operational experience. All the systems are rapidly expanding their data bases, however, and in a few months many should be fully operational and results of their carpool campaigns should be available.

SPECIAL PURPOSE CARPOOL SYSTEMS

Throughout this report most of the discussion is of systems intended to reduce the amount of vehicle travel associated with the journey to work. Most carpool systems are designed for work-related travel rather than other travel purposes because more travel is associated with employment than with any other single purpose, and because travel to and from work is regular and concentrated in time and place and is thus more readily subject to carpooling.

There is some potential, however, for carpooling for non-work travel, so this section will briefly review special purpose carpool systems. Carpool systems can be conceived for purposes such as recreation, shopping, or school. A few such systems are operating at the present time.

One type of system is the supermarket shopping carpool matching service. At least one supermarket chain in the Boston area has advertised such a matching service and has made its computer program available to other supermarkets through the National Association of Food Chains. The program matches on home address zip code, store location, and shopping day and time. From the brief review made for this study it does not appear that there has been very much response to this service (fewer than 1000 applications from the customers of 60 stores) but the service has been in operation for only a few weeks.[34,35]

Another matching service deals with recreational trips. WBZ and ALA in Boston included on their questionnaire a question relating to carpool travel to major sports events. Few applicants have requested this matching service, and matches are no longer processed on this question.

From this review it appears there is little experience with special purpose carpool matching systems. On the other hand, informal carpools for non-work trips are certainly in wide use; it is not uncommon for several people to travel together to shop, attend a football game, or go on a weekend ski trip. In fact, vehicle occupancy is usually much higher for non-work travel than for travel to work; auto occupancy rates of 1.6 to 2.4 persons per vehicle are typical for non-work trips.[36]

The difficulty with matching services for non-work trips is that such trips are irregular in time and place, often do not involve movements of statistically large groups of people at one time, and are usually undertaken at times when roadway congestion is slight and consequently the incentives for carpooling are personal rather than societal. Most such trips - particularly the growing amount of social and recreational travel - are undertaken outside of any institutional framework which would readily provide the opportunity or incentives for formal matching services. Certainly it would be undesirable and impractical to rigidly schedule shopping and recreation. A possible exception to this would be trips to and from school, which are fairly regular and may overlap peak commuting time as well. Some experience has been reported[33], but not enough to be conclusive.

Social and economic forces may well encourage substantial increases in special purpose, carpooling, however. Whatever trends tend to provide added inducements for work-related travel, such as frequent fuel shortages or preferential treatment of carpools on highway facilities, will also tend to promote increased, but informal and temporary, carpools.

SUMMARY AND OBSERVATIONS ON MATCHING METHOD AND DATA BASE

Summary of Experience Reviewed for This Report

Carpool matching systems reviewed in this study can be categorized as destination-based, regional, or combination systems. Experience with each type was summarized in this section.

Destination-based systems have been in use for the longest time and have served the largest total number of people, but as isolated systems have generally not affected the travel patterns of large numbers of commuters in any one metropolitan area. Special investigation of several large employers in the Boston area showed a lack of enthusiasm among these employers for the WBZ-ALA region-wide matching system. Employers cited several reasons for preferring their own destination-based systems, including the need for privacy of data and the low matching rate achieved so far by the WBZ-ALA system. This study showed that manual or semi-automated matching systems appear to be adequate for up to several thousand employees at one site.

Regional matching systems have been operated in recent months in several cities, chiefly by radio and television broadcasting organizations in cooperation with other elements of the private sector. These systems are characterized by intensive publicity and promotion and relatively simple matching processes. Of these systems, the WBZ-ALA system in Boston is the oldest and has attracted 15,000 applicants. The matching rate is now 25 percent. A system in San Francisco, in which a broadcaster participates but which is being operated by a coalition of organizations including both state and Federal government agencies, has attracted approximately 25,000 applicants although it is younger than the Boston system. Other systems have attracted even fewer applicants for matching service. While the data bases in these systems are continuing to grow, it is generally conceded that these systems have not attracted as many applications as had been anticipated.

Combination systems are the newest type of matching systems and appear to be the type most often organized in the recent past. Systems reviewed for this report are characterized by broad-based enthusiastic support from the community. Generally such systems use a dual approach of first attempting to encourage carpooling among employees of large employers and then combining data bases to provide a matching service for the general public. Of the systems reviewed, Connecticut's statewide system and

Denver's system have provided matching services to the most people. Several such systems can be expected to be in full operation and have substantial data bases within a few months.

Observations

Matching Rates - Matching rates (i.e., the percentage of applicants for matching who receive lists of potential carpool partners) vary widely among the system reviewed. The matching rates depend to a large extent upon the type of computer matching program being used. (These programs will be discussed in more detail in the next section.) In general, however, regional systems have matched 25 percent or less of their applicants whereas destination-based systems and combination systems based upon destination-based matching have exhibited matching rates of 50 percent or more. Regional systems appear not to have attracted enough applicants to provide matches for the tremendous number of possible combinations of origins (home addresses), destinations (work locations), work schedules, and personal preferences used for matching. (The higher matching rates for destination-based and combination systems result in part, however, because these systems tend to use more sophisticated computer programs than do regional systems.)

Potential - Destination-based matching may be advantageous to an individual employer and his employees, but unless such practices are widespread in an urban area there would be little impact on travel or air quality. Regional systems have the potential to provide matching service throughout a metropolitan area and in theory could reduce travel and air pollution. But such systems have not yet demonstrated their efficiency; the Boston system, the oldest one, has produced matching lists for only 2800 people. Regional systems have potential for air quality improvements only if much greater segments of the population apply for matching than have so far, or if such systems encourage people to form carpools on their own. Combination systems are also not yet proven, but because of their employer focus have a great potential for encouraging carpooling among large blocks of commuters.

In the systems studied, there is some indication of the impact of incentives. Generally, incentives have resulted in measurable increases in the number of actual carpools, not just in applications for matching service. This result occurred in cases with non-automated matching services as well as in cases with sophisticated computer matching services.

Advantages and Disadvantages - Destination-based matching systems have the important advantage of a strong identification between the system and the employer operating it. This can lead to a high degree of cooperation and participation both within the employer management and among the employees. From a public standpoint, such systems have the major disadvantage of being uncoordinated between employers and probably being used only in isolated cases (i.e., only a few employers will use them without the pressure of outside forces) and consequently cannot be relied upon for reducing vehicle travel and air pollution. (This disadvantage could be overcome by regulation or by other means to restrain travel.)

Regional systems have the potential advantage of providing matching service throughout a metropolitan area for all commuters regardless of whether they work for an employer who participates in a matching system. Such region-wide service can conceivably provide a means for carpool service for people who have unusual travel habits and need a large data base in order to locate carpool partners. Unfortunately such systems have not yet demonstrated their ability to attract enough applicants for large numbers of people to be matched. Most such systems lack the personal identity, privacy of data, and personal service destination-based systems have provided. On the other hand the promotion of regional systems may tend to improve the public's concept ("image") of carpooling and thus encourage greater use of carpooling outside of the formal system.

Combination systems have the advantage of destination-based systems in being identified with the employer and having a demonstrably high matching rate which can inspire confidence and wide use of the system. For region-wide use such systems can potentially provide a very large data base for general population matching, provided privacy issues can be resolved. Such systems have the greatest potential for reductions in travel and air pollution. One disadvantage of such systems may be the amount of effort, time, and cost involved with preparation and operation of a system satisfactory to large numbers of employer organizations.

Best Approach - First, it must be said that it is probably premature to conclusively decide what is a best approach; there simply is too little experience. Second, local conditions vary so widely that there probably is no "best" approach. Within these limits, however, the experience reviewed for this report implies that a dual approach should be used, similar to the Denver or Knoxville combination systems. A coordinated effort should be made to encourage carpooling among as many commuters as possible. To this end, the effort should be directed first at the employers who employ the majority of the metropolitan area; wherever possible, employer data should be pooled together to form a substantial data base for matching people who do not work for major employers or who have unusual travel requirements. Overall system operation should be managed by a coalition of government, business, and the public, with strong support elicited from major employers.

SECTION IV

MATCHING SOFTWARE

GENERAL

This section of the report will discuss the computer programs which perform the actual matching process to identify potential carpool partners. Experience with several programs now in use will be summarized, and programs being developed or being revised will be reviewed.

Some destination-based carpool systems do not use computers for matching, or use computers only for generating lists of potential riders by home address rather than for actual matching. Some of these non-automated matching systems were discussed in Section III and consequently will not be further reviewed in this Section. For additional information on manual matching techniques, the reader may wish to refer to the FHWA or HUFSAM reports listed in the Bibliography.

REQUIREMENTS AND CONCEPTS

Any computer program, or family of programs, used for carpool matching must perform certain functions. Of foremost importance is matching on the basis of home address and work schedule. Matching on the basis of work location may or may not be performed, depending upon whether the system is used for regional matching or for destination-based matching. Some computer programs match people on other criteria, including one or more of drive/ride preference, frequency of carpooling, smoking preference, male/female companion preference, and carpooling for non-work purposes. The requirements for matching of these various characteristics will be discussed in the following sub-sections.

Origin Coding And Matching

There are two basic steps associated with matching origin (home address) information for a particular carpool candidate:

1. Defining and identifying the area in which the home address is, and
2. Determining other potential carpoolers with home addresses near the candidate's.

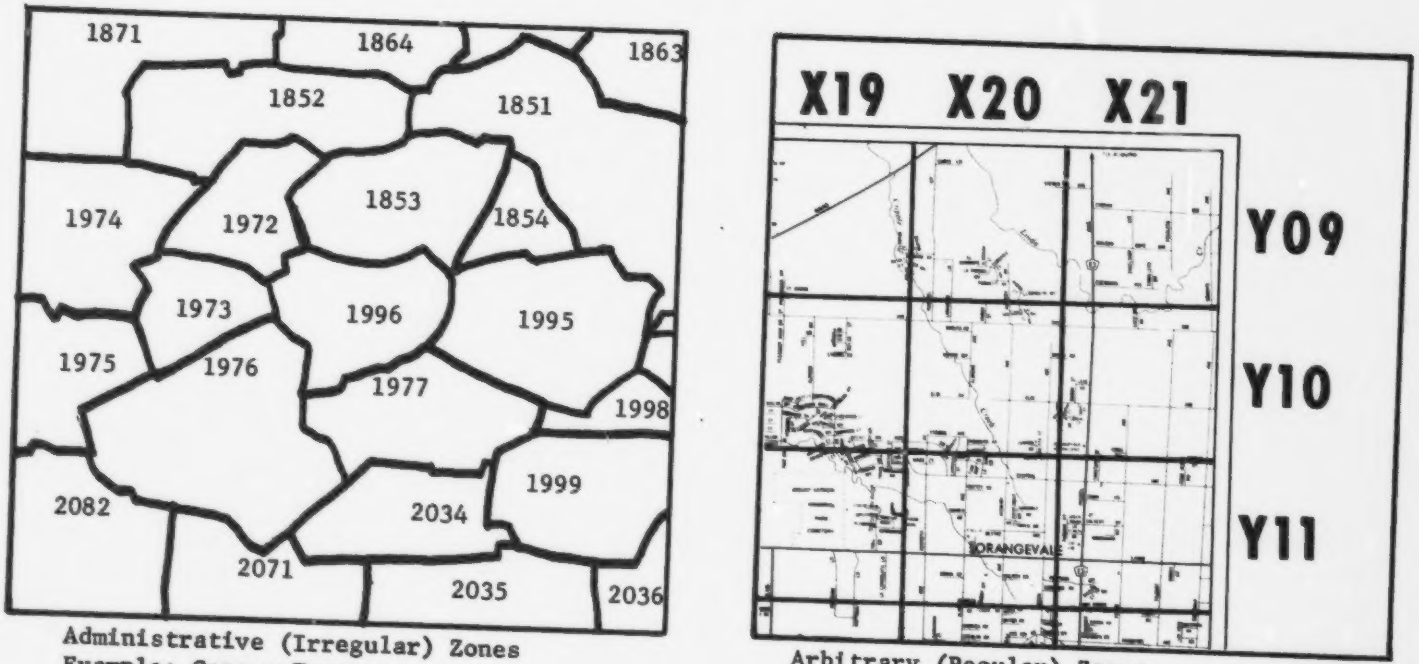
Designing the matching system thus requires designing the method for identifying home addresses in a way the computer can work with and designing the method for searching among the data for addresses of carpool partners near the candidate's home.

Origin Coding - Home addresses can be handled in the computer in several ways. Theoretically, one way would be to work directly with the street addresses and retain in the computer's memory some sort of "map" which mathematically related the addresses to each other. This map would enable the computer to calculate the distance between one home address and another in order to determine the best potential carpool partners.

Such a process could be done in two steps. First, the home address would be converted to a numerical code representing the spatial location of the home. For example, the address could be coded in rectangular (x and y) coordinates from a fixed reference point on the map. Next, the computer would work with the coordinates of all the candidates to algebraically calculate home-to-home (or home-to-work) distances.

Another way to work with addresses is to divide the metropolitan area into zones and identify each zone and all addresses within it by a single number. Such zones can be either administrative designations or arbitrary. Administrative zones could include the postal zip codes, municipalities (assigning a unique number to each), census tracts, or state highway department traffic zones. Arbitrary zones could include such techniques as the use of a rectangular grid pattern which would be superimposed on a map of the area. Irregular patterns or irregularly numbered patterns, such as zip codes, would probably prevent the use of some types of matching processes because it is difficult to describe in mathematical terms how zones in these patterns are arranged. Storing a "map" of the system would add to the length and cost of a program. In contrast, regular systems such as rectangular grids are more readily used for computations because there is a one-to-one relationship between the grid designation and its physical location. These concepts are illustrated in Figure 1. On the other hand, administrative zone systems may require less clerical work outside the computer. The use of zip codes or municipalities requires little or no extra work because they are directly identified by the address supplied by the applicant, whereas the use of x and y coordinates requires the determination of the coordinates for each home address, which might be a time-consuming clerical process. With some arbitrary systems such as grids it may be possible for applicants to code their own addresses but such systems may lead to confusion and errors on the part of many applicants.

Another choice involves the size of zones. Small zones may contain too few candidates for good matching opportunities; large zones may include more candidates but homes in one zone may actually be too far separated for convenient matching. One way to overcome the difficulty of zone size selection is to use a matching process which involves matches among adjoining zones; with such a process the actual zone size is less critical.


1871
1864
1863
1852
1851
1974
1972
1853
1854
1973
1996
1995
1975
1976
1977
1998
1999
2082
2034
2071
2035
2036
X19
X20
X21
Y09
Y10
Y11
ORANGEVALE

Administrative (Irregular) Zones
Example: Census Tracts
(Adapted from Reference 38)

Arbitrary (Regular) Zones
Example: Grid System for Sacramento, Calif.

Figure 1. Geographic Coding Concepts

Origin Matching - Several types of matching logic can be used, depending upon the type of origin coding and the type of computer program.

Single-step matching selects all the home addresses in the same designated area. All addresses in one zip code, one town, or one grid square are identified as potential partners (subject to the constraints of destination, work schedule, etc.).

Multiple-step matching selects all the home addresses in the same designated area and then if necessary selects additional addresses in adjacent areas. Typically, a minimum number of matches is established, such as eight people with the same destination and work schedule. If this minimum number of potential partners is not found in the first zone searched, additional zones are searched. In a rectangular grid, the first zone (or cell) would be the zone in which the candidate lives. Next, all the eight adjacent zones in the grid would be examined for potential partners, and so on. With a system based upon x and y coordinates rather than zones, searching can proceed inside circles of increasingly-wider radius until the desired quantity of matches is determined.

Another type of searching involves searching along the route of travel rather than searching in the origin's vicinity. Using some criterion for nearness of the potential partners to the candidate's route, the computer program would locate potential partners along the route from the candidate's home to his job. The route could either be the actual route along the street network, which may involve extensive mathematical modelling of the highways, or the straight-line route between origin and destination.

With any type of search mode, a related issue is that of the quantity of matches. Two approaches can be used: exhaustive and minimum number. In the exhaustive method, all candidates meeting certain criteria are listed together. Typically, a program with zip code origin coding uses an exhaustive search. All persons living in the same zip code are listed (provided they meet the destination and schedule criteria), regardless of whether the quantity is one or one hundred. With the minimum number approach, searching continues until a specified minimum number of matches is obtained. With x-y coding, for example, the program may search circular areas with increasing radii until at least eight matches are obtained.

In summation, selection of the origin coding and matching process involves some compromises among speed, complexity, flexibility, clerical effort, and matching success.

Destination Coding And Matching

Destination coding and matching involves similar concepts to origin coding and matching. Destinations are apt to be more concentrated than origins, however, which alters the techniques somewhat. In addition, some computer programs are designed for destination-based systems and destinations are thus not searched.

Destination (work location) matching involves the same two basic steps as for origin matching, namely:

1. Defining and identifying the area in which the destination is, and
2. Determining other potential carpoolers with destinations near the candidate's.

Destination Coding - Destinations can be coded in the same ways as origins (home addresses), including grid systems, direct x-y coding from addresses, and use of zone designations. In practice, larger administrative zones such as zip codes or municipalities would be difficult to use because an excessive number of destinations or an excessively large area could result. With too large an area, potentially matched locations might be widely separated in travel time because of traffic congestion or might include awkwardly large numbers of potential partners.

An additional type of coding useful for destinations is landmark or area coding. General vicinities can be described verbally and assigned an identifying number. Verbal descriptions would include terms familiar to local people, such as "Government Center," "Post Office Square," or "Jonesville Industrial Park." Size and distribution of such areas can be varied to suit local conditions, taking into account such considerations as employment density, relative locations of designated areas, highway network, and transit connections. Park-and-ride facilities for railroad or mass transit service can be included in this type of destination designation, thereby facilitating the coordination of travel modes.

Destination Matching - Carpooling candidates can be expected to prefer that potential carpool partners work relatively close to the candidate's workplace. Traffic congestion is apt to be greater in employment centers than in residential areas, so it would involve more time and stress to travel a certain distance among work locations to pick up passengers than to travel the same distance among homes to pick up passengers. People are more likely to know something about firms physically near their own and thus may be more willing to carpool with employees of nearby firms. In the matching process itself, the maximum distance between the workplace of the applicant being matched and other workplaces should be chosen so that the matching process does not identify either too many potential partners, making selection a cumbersome process, or partners so distant they will be rejected by the applicant.

As with origin matching, either single-step or multiple-step matching can be used for destinations. With single-step matching, all workplaces in one grid square or zone number would be searched for matches.

With multiple-step matching, additional grid squares or destination zones are searched if insufficient matching results from the initial zone. Also, as discussed in connection with origin matching, destination matching can be based on an exhaustive listing of all matches meeting certain criteria, or based on a criterion of a minimum number of matches regardless of distance.

There is no need to use exactly the same criteria for destination matching as for origin matching. In matching people who work in the central business district (CBD) of a large city, for example, exhaustive one-step matching may be suitable for the CBD destinations whereas minimum-number multiple-step matching may be more suitable for origin matching in the same program. Of course, use of two different matching techniques may cause the computer program to be more complex, but at the same time such techniques can increase the overall speed and utility of the matching system.

Coding And Matching Of Work Schedules

The problem of matching work schedules is more difficult with regional or combination systems than with destination-based systems because of the greater variety of possible schedules. Yet this aspect of matching is also very important, because carpooling will not succeed if the carpool either jeopardizes the punctuality of a member or requires significantly longer work days for him in order to accommodate the other members of the pool. On the other hand, lack of flexibility could result in fewer potential matches.

Work Schedule Coding - Coding of work schedules can either be continuous or discrete. That is, applicants for matching may be asked to either identify their own exact working hours (e.g. 8:10 a.m. to 4:45 p.m.) or to round off their work schedules to fit a specified list (e.g. start at either 8:00 a.m. or 8:30 a.m. and finish at either

4:30 p.m. or 5:00 p.m.). If the applicant specifies his work hours exactly, rounding may be done by the matching system operators or may not be done at all. If the applicant does his own rounding off, he may be able to more accurately judge his flexibility than could the operator of the matching system. For example, a professional person whose office nominally works from 8:30 to 5:00 may be able to easily accept arrival at 8:45 and departure at 5:15. So if rounding is to be done, the applicant may be better suited to do it.

If rounding is done by the system operators, with the applicant's data, some rules must be established. Without foreknowledge of the applicant's flexibility, the system operator should presume that the applicant specifies the latest time he may arrive; thus, if the applicant specifies 8:10 a.m. as a start time and times are to be rounded to the quarter-hour for processing, the next earlier quarter-hour, 8:00, should be specified to the computer. (The questionnaire should explicitly identify to the applicant that he identify the latest time he can arrive, earliest he can leave, etc.) Departure times would be rounded to the next later time period, as from 5:10 to 5:15.

Work Schedule Matching - Computer programs can either match people only with others whose schedules are identical, or match those whose work schedules fall within a range. Matching to exact specified schedules would only be done with previous rounding of work schedules so that there would be a reasonable chance of matching. Matching within a range would involve either pre-rounded or un-rounded times.

Matching within a range of schedules would be more appropriate and more essential in cases where either few applicants are involved or many work schedules are involved. The same sort of trade-off prevails with schedule matching as with location matching, namely a compromise between narrow criteria with few matches and broad criteria and many matches.

Coding And Matching Of Other Criteria

Besides location and schedule criteria, potential carpool partners can be matched on numerous additional criteria. The more criteria there are, however, the fewer the chances of matching each individual. With large data bases and small variations in schedules, such as with destination-based matching systems, matching on additional criteria may be more feasible than with regional systems where good basic matching service for an entire metropolitan area is desired.

Matching criteria in the optional category include the following:

1. Whether applicant wants to drive, ride, or both.
2. Whether he has a preference regarding smoking or non-smoking.
3. Whether he prefers only male or only female carpool partners, or only married or unmarried partners.
4. Whether he wishes to use a carpool occasionally or regularly.
5. Whether he sometimes works overtime and wants to be matched for additional work schedules.
6. Whether the applicant wishes to be matched on other preferences, such as with only people from same employer, only people of same age group, only people of similar education, etc.
7. Whether the person wishes to obtain matches for non-work purposes such as sporting events.

These possible matching criteria all can be considered personal preferences. The use of such criteria for matching would be based upon the concept that carpools are more apt to succeed with compatible people. The validity of this concept is yet unclear but may be shown shortly by experience with the Knoxville system, which uses an elaborate questionnaire based upon this concept. The difficulty is that specifying too many such preferences could lead to low matching rates. An alternative to actually matching on these preferences is to merely identify the applicant's preferences in the data sent to each applicant; for example, the list of potential partners could state the smoking/no smoking preference for each name and allow the person using the list to make his own decision of whether to contact another person whose preferences differed from his own.

Overall Matching Rates

Given the variety of matching criteria, it is apparent that the matching system design will affect the rate at which applicants are matched with potential carpool partners. Design of the matching system must strike a balance between the quality of matches and the quantity of matches.

One widely used indicator of the success of a matching program is the rate at which applicants are matched, or the matching rate. In most instances this is expressed as a percentage; for instance, one would say that 30 percent of the applicants were matched with at least one other person. The use of such rates are useful indicators of how well the service is operating in the sense that higher matching rates imply that more people will be provided data enabling them to form carpools. In evaluating the design of a matching program and trying to decide which of the matching criteria discussed above to use and how strictly to use them, matching rates can be used as an indicator of the program's utility. Programs with strict, narrow, multiple criteria will achieve fewer matches than programs with few, broad criteria.

On the other hand, the use of matching rates can be deceptive. As stated above, there is the issue of the quality of the matches; a long list of carpool candidates is of small value to the applicant if most of those on the list would require substantial compromises of travel time, work schedule, travel distance, or personal preferences. Great compromises will lead to unstable, short-lived carpools.

Carpool matching programs which use a minimum-number-of-matches criterion for matching can always have apparent high matching rates, but may be no more effective at promoting carpools than other programs which use better matching criteria but may exhibit lower matching rates.

Furthermore, any program will deliver higher matching rates with more data. A low matching rate may not imply the failure of the program but rather the failure of the total system to achieve enough applicants. Matching rates should increase in time as the data base grows in size.

Consequently, matching rates should be compared carefully. While a high matching rate is generally desirable, and while the matching rate is one of the few quantitative indicators of the utility of a matching system, the value of a system should be judged by other criteria as well.

What is needed, but what is not yet available, is an indicator of the rate at which a carpool matching system results in the formation of carpools. As will be discussed elsewhere, there are as yet few data on the rate at which carpools are formed through any system. More important still, there are even fewer data on the long-term steady-state use of carpools; most data are for short-term results from programs instituted within the past few months.

Additional material on the carpool matching program matching rate is in Section IX.

Output Form

Most matching programs are designed to produce output in a form which can be directly used by the applicant. The most widely-used format is that of a letter, addressed to the applicant, and identifying his potential carpool matches. The output format is not critical except that it should include enough information for the applicant to decide whom to contact and how to contact them. For destination-based systems the output can be fairly simple. For region-wide systems more information must be supplied.

For regional systems the minimum output information for each potential partner appears to be:

1. Name
2. Telephone number where he can be reached
3. Some indicator of where he lives and works, either his address or some portion of it or the distance to his home, and his work location or the distance to it
4. Work schedule.

Optional information which either could be on the output form or which the applicant might ask for in a telephone call could include:

1. Information on preferences such as smoking, ride/drive, etc.
2. Personal characteristics such as age, sex, education
3. Employer name
4. More detail on employment location, home address (but see discussion of privacy issue below).

With respect to such optional information, there is an obvious need to provide enough information for the applicant to decide who to contact. On the other hand, the publishing of lists with preferences and other data which may be considered "personal" may tend to discourage use of the system. In the beginning, when such systems are first in use and the data bases are small, there appears to be little danger in printing only essential information. As data bases grow and lists of potential partners become inordinately long, then perhaps more optional information should be printed on the output.

Privacy And Security

One major difference between destination-based, employer-operated carpool matching systems and regional matching systems is the greater need to provide privacy and security features in the regional system.

The need for privacy and security of personal data is perhaps not apparent. In addition it is not clear that the security/privacy issue would in fact arise to the degree postulated here. It may indeed vary among the parts of the U.S., but throughout the research for this report the privacy/security issue was continually mentioned in discussions of the merits of various types of matching systems.

In the Boston area, for example, all the firms who were contacted and who had decided to carry out their own carpool matching system rather than only provide questionnaires for the WBZ-ALA system mentioned the privacy/security issue as at least one reason, and often a major reason, to undertake a separate employer-based system.

There are two personal dimensions to this issue. One aspect can be referred to as the privacy issue and amounts to a fear of misuse of the data by those who are provided it by the matching service. Objections to providing personal information include the fear of being disturbed by telephone calls or mail from numerous strangers, the fear of persons who would use the information for criminal purposes (such as to commit burglary during the work hours), and the fear of being asked to form carpools by persons who may be intending assault, robbery, or other illicit behavior, or may simply be people of a different social, economic, or cultural class with whom the applicant would not wish to ride.

The other aspect regards the security of the information and amounts to concern over misuse of the data by those operating the system. One concern might be that lists of carpool applicants would be sold to advertisers, much as license plate registration lists are now sold.

There is an additional institutional element to this issue when discussing combination systems wherein employers submit blocks of data to a central system. Employers express reluctance to provide data which they feel could be used to their disadvantage. Some seem to fear that other firms (their competitors) will determine how many employees they have, or that someone will in some other way abuse the collective data. One administrative officer objected to pooling data with a nearby competitor because he feared the formation of carpools might lead to exchange of information on employee salaries.

Some of these fears may be ill-founded; others may be fears expressed theoretically without their actually existing among many of the populace; others may be seen as trivial. Nonetheless, the existence of these concerns among those who influence the operation of such systems, such as company administrative officers, must be reckoned with. Regardless of the merit of the fears they must either be assuaged or used in the system design.

The best solution to the privacy issue appears to be three-fold:

1. Design the system to provide potential applicants every reason to trust the system to protect their privacy. The officials who administer it should be as well-known and trustworthy as possible. As an end to this, internal company distribution and collection of carpool questionnaires has great potential because it enables employees to deal personally with people with whom they work every day, and it minimizes the amount of personal information in the output. The literature should clearly state how all personal information is used and protected.
2. The output should provide as little personal information as is reasonable for good matching. An office telephone can be printed in lieu of a

home telephone. Street addresses should not be printed.

3. Provide safeguards so that employer data cannot be provided to others than the employer or the system operator. That is, prevent the compilation of lists by employer which could be misused and violate an employer's trust in the system.

The concern over this issue may be premature; regardless, sensitivity to it may result in more successful carpool systems.

Maintenance

One purpose of carpool systems is to initially cause an increase in the use of carpools by assisting in their formation. A second purpose is to maintain a desired amount of carpooling by providing a continuing service to people. New service would be needed when a carpool member changes jobs or home address or work schedule, when a new employee joins the firm, or when a new resident moves into a region.

One way to provide the matching service for such changes would be to re-run the entire program at stated intervals. For example, the entire carpool survey could be re-run every six or twelve months. This would be feasible for some destination-based systems but may be burdensome for large systems. In addition, this delays the provision of carpool matching data to people whose needs have changed.

Another way to provide this maintenance function is through central files. With a suitable filing system all the existing data could be organized to permit one-at-a-time manual matching. A new applicant would write or telephone the agency which administers the carpool system, provide his address, work location, and other matching data, and be given the names and telephone numbers of several people with compatible characteristics. This process could become expensive for large data bases, however.

A third way is to utilize a special computer program designed to only edit, correct, or update the prior output. Such a program would search the files for only the applicants whose characteristics are being revised, match, and print out matching lists only for these revised applicants. Such a program allows automated revisions in large data bases, at modest cost.

Transportation Planning Data

Questionnaires for carpool matching service may be a useful way to obtain data on transportation needs and characteristics. Several operational computer programs include analysis of questions relating to past or present transportation habits, preferences for transportation systems, travel times or routes, and other information of value to transportation planning. Programs generally would separate these data from any data used for matching candidates and instead prepare special output for use by planners. One use of such data is to identify the potential for vanpools or buspools, new bus routes, or increased transit service among those interested in carpools.

One form of such output is a density matrix, which shows the number of origins from within one area (one origin zone, say) to a particular destination (the CBD, say), thus revealing where there are concentrations of travelers with similar origins, destinations, and routes.

Inclusion of transportation planning functions in a matching program has the potential for great increases in the utility of the program for planning purposes with but small increases in overall costs.

PRESENT CARPOOL MATCHING SOFTWARE

General

The first part of this section of the report has outlined some general concepts of how matching programs operate. With these concepts in view, this portion of the report will review several computer matching programs now in use.

It should be borne in mind that computer carpool matching as a concept is only a few years old and that few carpool matching systems have been in operation for more than a few weeks or months. Thus it is probably premature to judge how well particular programs will work as part of an overall system, even though some indication may be gotten of how the programs themselves operate. Thus, as was discussed earlier, what is still needed is a measure of how much carpooling actually results from the operation of the various matching systems.

Carpool matching is in a very dynamic state as this report is being written. Programs are being revised as they are used, new programs are being written, and other programs are being discarded. Many programs are written in several versions for different circumstances or applications, and there is more experience with some versions than with others. Furthermore, this report does not review all computer programs and may omit some which later prove to be of great importance.

Examples Of Existing Programs

Widely Used Programs - Several computer programs for carpool matching are well documented, have been widely distributed, and are in use in multiple systems. Three of these will be described here. For additional detail and for how to obtain these programs refer to the References and Bibliography. The descriptions below are based in part upon References 29 and 37.

FHWA Carpool Matching Program - The program prepared originally in 1972 by the Federal Highway Administration (FHWA) has subsequently been distributed to approximately 190 agencies and companies. The program is very well documented (see Bibliography), is available free of charge to anyone planning to operate a matching system as a public service, and is written in the American National Standards Institute (ANSI) COBOL language.

Origin and destination coding are done by a grid system. Grid cells are square or rectangular, and the array includes a maximum of 49 cells in each direction, or a maximum total of 2401 cells in the area to be coded. To provide more detail in downtown areas, the program permits the use of two grid cell sizes simultaneously, with the inner (smaller) grid cells being half the length and width and one-fourth the area of the outer grid cells.

Origin matching searches for matches in the eight cells around the origin cell if at least eight matches are not found in the origin cell. Work schedules can be matched exactly, or a range of work times can be specified. There is no search at the work end. Each work grid cell is matched separately. The program evidently was written chiefly for destination-based matching, and is inefficient for region-wide matching. FHWA plans to revise this program to include a search of adjacent grid cells at the destination end.

The grid system can be limiting to the use of this program for regional matching because of the coarseness of the grid. FHWA recommends a grid cell of one mile square. In many metropolitan areas this would be too large an area for destination matching in major employment centers. If smaller grid cells are used, they may be too small for effective matching in suburban or fringe areas where transit is poorest and carpool potential the greatest.

Special conditions can further complicate this. In Dallas and Fort Worth the FHWA computer program is being used for a regional matching system, but with the two cities it was not possible to use a detailed grid in both cities. However, the grid used has a variable cell size, varying from about one mile wide in the downtown areas up to two miles wide in some outlying areas. Nonetheless, the one-square-mile grid cells encompass dozens of city blocks in the two downtown areas. (Dallas is considering modifications to the program to overcome this potential problem.)

In their report to FHWA, a consultant surveying the available software criticized the FHWA program for its excessive output of "extraneous data." Also, some users have reportedly had difficulty adapting the program to some types of computers.[29]

Census Bureau Carpool Matching Program - The Census Bureau's "Census Use Study" has developed a carpool matching computer program designed to take advantage of certain computerized census data. There are about 200 metropolitan areas where Dual Independent Map Encoded Geographic Base Files (DIME/GBF, or just DIME files) have been compiled. These are files of the topological features in a metropolitan area in a form useful to a computer. In essence the DIME files identify which census tract contains a given street address. The Census Bureau carpool program thus uses as an input the identity of the census tract in which the applicant's origin and destination are located. In cities where the DIME files are current, the use of this program reduces the work involved in geo-coding; unfortunately, however, the DIME files are not up to date in many cities and are most out of date in the developing fringe of metropolitan areas where carpooling has the greatest potential. Nonetheless the DIME files can assist in geo-coding; the Census Bureau program is being used in San Francisco with the DIME files, and manual geo-coding is used to supplement the DIME files.

In addition, the Census Bureau states that their program can use any alternative form of geo-coding such as zip codes, and the documentation describes a manual process for using census tract maps with their program.

The Census Bureau program documentation was recently published but the program has subsequently been revised. Potential users should contact the Data User Services Offices for the latest information. The following description is based upon Reference 38.

In operation, the centroid of the census tract (or other zone) is established and identified by x and y coordinates. Matching on the origin end involves first the origin census tract and then all surrounding tracts whose centroids are within a predetermined distance from the centroid of the origin tract. This process continues, with expanding radii to the centroids of surrounding tracts, until either a minimum number of matches is reached or until the distance to the centroid of the surrounding tracts being searched is equal to the distance from origin to destination. Searching surrounding tracts on the destination end is not included in present documentation but is planned as a later modification.

Matching on work schedules uses criteria established by the user. Other criteria include common work days and drive/ride preferences.

The program was written in FORTRAN and is fairly complex. Little user experience has been documented.

The revised version of this program being used for the San Francisco carpool matching system incorporates several additional features. Multiple destinations are now provided. These destinations are described as landmarks, major employment centers, or other areas. Destinations not in the standard list are coded by their zip code.

Destinations are assigned x/y coordinates for use within the program. Besides the search for matches among adjacent zones on the home end, the modified program searches for matches among destinations whose x/y coordinates are within a specified radius of the applicant's destination. The potential matches are ranked for their suitability according to a method which assigns weighted values to the nearness of potential partners' homes, nearness of destinations, degree of agreement in work schedules, etc. The matches with the best "score" from this process are then listed in the output, rather than just those matches meeting set criteria. This program has been used for the first 15,400 applications, and the results are being analyzed. Further refinements in the program itself and in the weighting factors are expected to result from this analysis. (Of the first 15,400 applications processed, 13,000 received matching lists with an average length of twelve names, but some matches appear to be of little use.)[20]

Burroughs "Operation Energy" Matching Program - Of the firms in the private sector, Burroughs Corp. has probably done the most to promote the use of computer matching. Its "Operation Energy" package, consisting of the computer program description as well as management suggestions, is provided free of charge to any organization desiring it. The description below is based upon that package, Reference 39.

Origin coding is based upon a grid system, with grid cell size determined by the user. Only a single cell size can be used, but the grid can be as large as 99 by 99 (9801 cells). Within the program, the x and y coordinates of each cell are used rather than just the cell designations. For destinations, a combination of grid and numeric designations is used. Up to 99 destination designations are defined. These can be described to the applicant as areas, landmarks, buildings, or other points. Within the program, the x and y coordinates of the destinations are used in matching.

In matching, the user specifies the minimum number of matches. The program matches only applicants with the same destination code; there is no work-end searching. Work schedules are matched within a range of 15 minutes. Within the constraints of destination and work schedule, the computer program locates suitable partners in the same origin grid cell. If the predetermined minimum number is not found within the same origin cell, adjacent cells are searched. The first adjacent cell searched is the one most nearly in the direction from the origin of the applicant to his destination; this is the reason the computer needs the x/y coordinates of origins and destinations. The other adjacent cells are searched until the minimum number of matches is achieved, working from the cell most in the direction of travel to the cell in the opposite direction. If the search of adjacent cells does not achieve the number of matches desired, the next ring of surrounding cells is searched, again beginning with the cell in the travel direction. This process continues until either the desired minimum number of matches is achieved or until a predetermined travel distance is reached; each applicant may separately state how far (i.e., how many grid cells) away from his home he'd be willing to travel. The directed, or vector, search pattern is an unusual feature of this program.

The program is written in ANSI COBOL, is reported to be suitable for small computers, is well documented, and has been used by several industrial sites for up to several hundred matches. Output can be tailored to either one-company, multi-company, or regional use. One option is that the operator can specify matches only among employees of the same firm while still using the program for several firms simultaneously.

Other Current Programs - The three programs described above are well-documented and widely disseminated. The next programs to be described are less well documented and less widely promulgated but merit interest.

Denver, Colorado, Carpool Program - Section III of this report described the Denver, Colorado, carpool matching system. As pointed out there, the matching program was written by high school students, and the program has not yet been well documented. Because of this, and because of the unique matching logic, the program will be described here in some detail. This description is based upon telephone conversations with those involved. Note that the program has been changed since Reference 29 was written.

The geo-coding (digitizing of addresses) process involves assignment of numerical (x and y) coordinates to the home address and work address. At the present time this is a manual process and is relatively time-consuming. In the initial efforts this work has not been a major obstacle because students or other volunteers can do the coding. But for a full-scale effort geo-coding is a potentially significant cost. The digitizing of addresses is essential, however, because of how the matching program works, as will be described. It is estimated that a person can digitize 200 to 300 addresses per day by hand.

A computer program has been developed which would permit machine digitizing of addresses. It is estimated that this would cost $10-15,000 for the Denver area, and has not been done because of a lack of funds. A similar program could be adapted to other cities, and reportedly could be adapted to curving streets as well as to the more or less regular street network of Denver.

The matching process itself operates in several steps. Before entering the data, starting times for work are rounded to the next earlier half hour and quitting times are rounded to the next later half hour. The computer then groups all people with the same (rounded) work schedules in a file and operates on one such file at a time. Next, the machine selects a list of potential carpool partners for each person in the file. To do this, it first examines the file for persons whose work addresses are within a one-mile radius of the applicant's work address. (This radius can be altered and 0.2 mile has been used for some large firms.) The computer calculates the distances between the homes of the applicant and his potential partners. The machine keeps track of the ten names whose home addresses are closest to the home of the applicant and who work within the 1-mile radius. This is the "cluster method." (See Figure 2.) If the third-closest person is more than two miles from the applicant's home, however, the matching process goes into another mode, the "vector search."

In the vector mode, the computer uses a more exhaustive way to examine the list of people who work within the 1-mile radius of the applicant. Potential partners are rejected if their homes are outside a circle with its center at the applicant's place of work and a radius equal to the distance from the applicant's home to his place of work (see diagram in Figure 3). For each potential partner inside this circle, a computation is made of the extra distance the applicant would have to travel to pick up the potential partner. This extra distance, referred to as "displacement," is a measure of the inconvenience or disruption involved in carpooling. The measure is imperfect because airline distances are used instead of travel distances, but provision of eight names should reduce the difficulties with that compromise. It is believed that this "vector search" technique is unique to the Denver program. Using this displacement as a measure of the suitability of a potential carpool partner is considered by the program authors to be superior to, and more flexible than, methods based on grid designations, zip codes, or other techniques of coding home addresses.

The matching program was written in FORTRAN IV, originally for a UNIVAC 1106/1108 computer. It is now being adapted to an IBM 360/50. On the UNIVAC, processing 500 people takes about 5 minutes. About 64K core storage words are needed for 2000 applicants. The amount of memory needed is proportional to the number of applicants in the

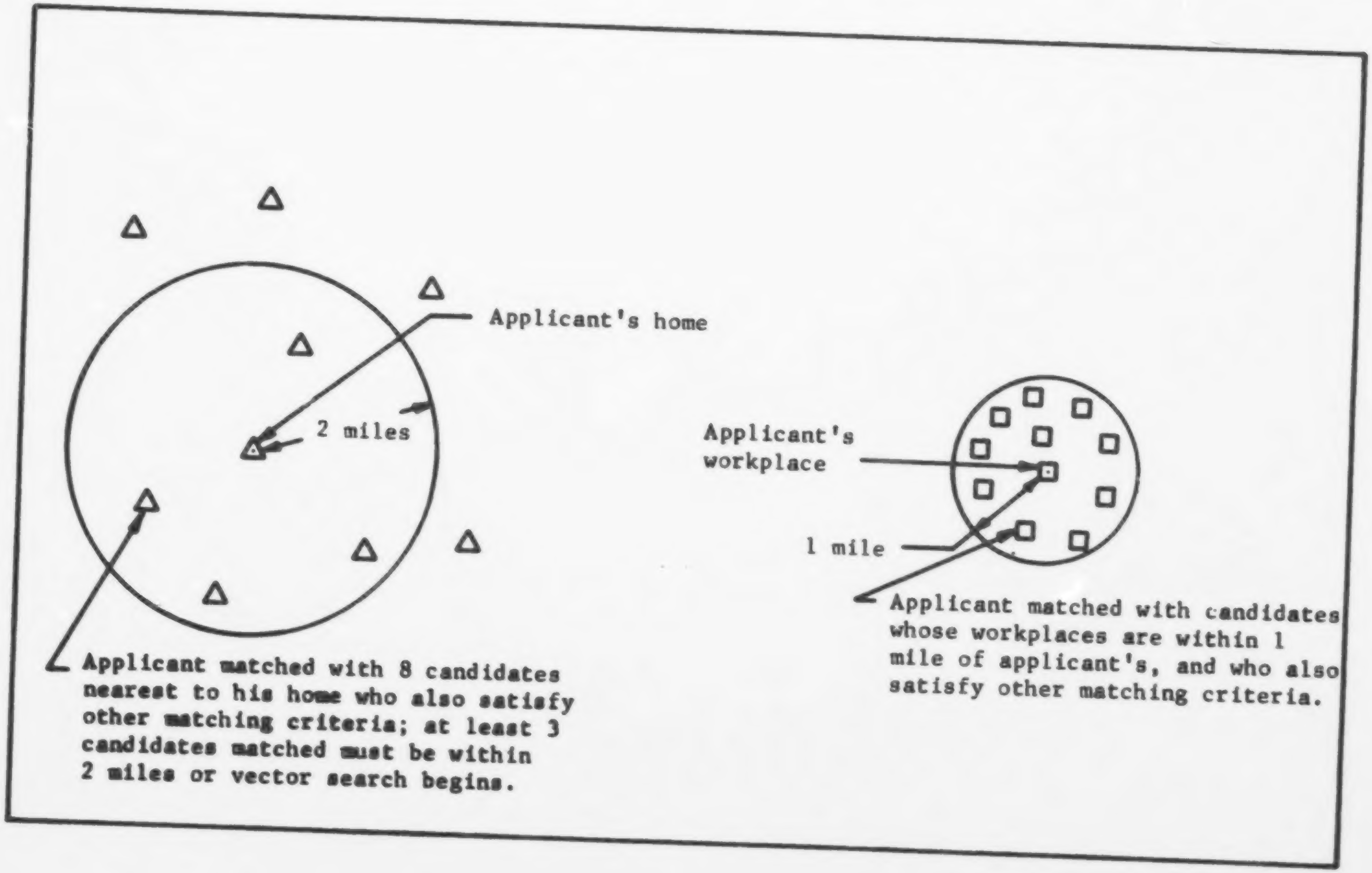

Applicant's home
2 miles
Applicant matched with 8 candidates nearest to his home who also satisfy other matching criteria; at least 3 candidates matched must be within 2 miles or vector search begins.
Applicant's workplace
1 mile
Applicant matched with candidates whose workplaces are within 1 mile of applicant's, and who also satisfy other matching criteria.

Figure 2. Cluster Search Method in Denver, Colorado, Carpool Matching Program

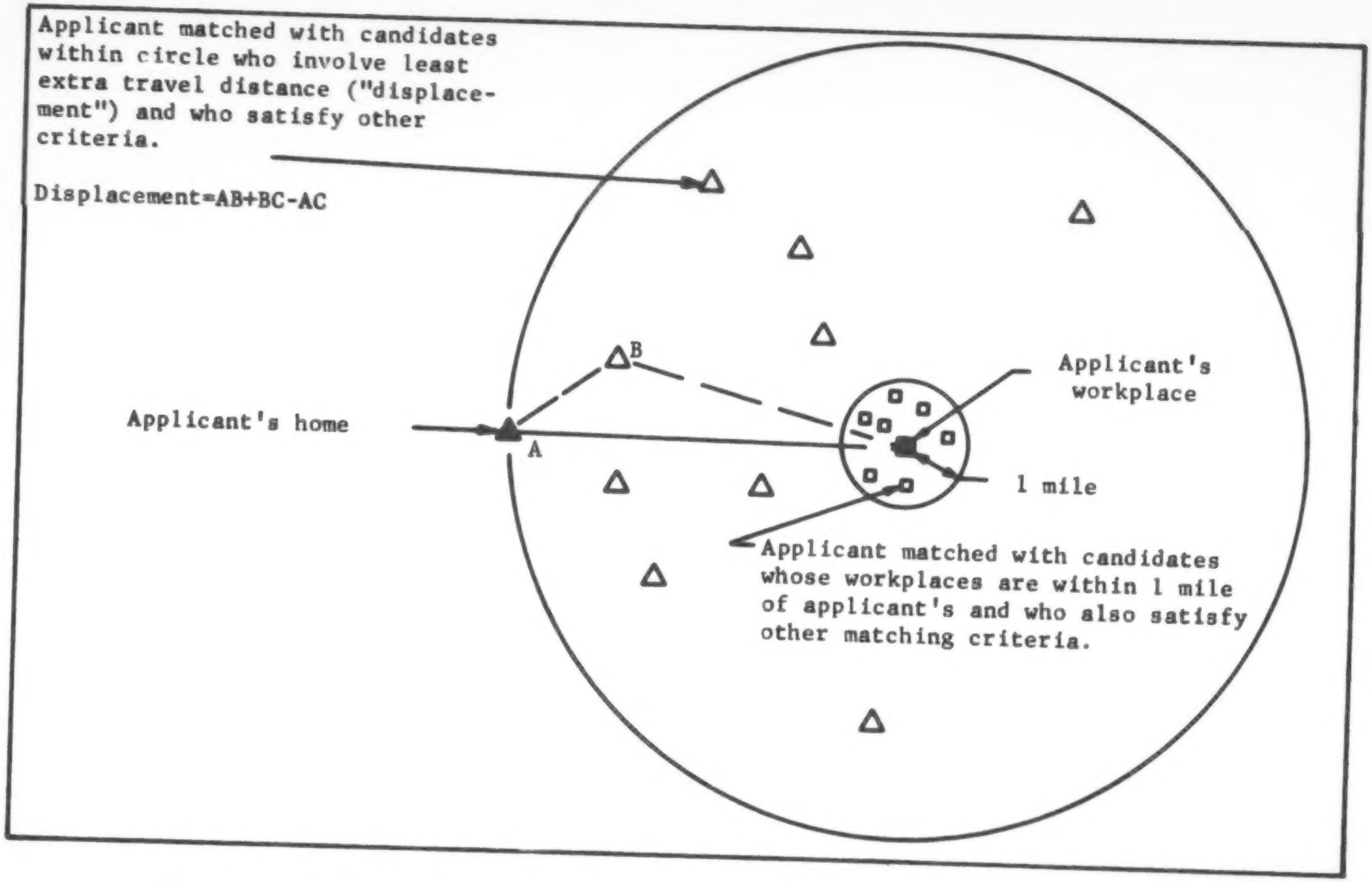

Applicant matched with candidates within circle who involve least extra travel distance ("displacement") and who satisfy other criteria.
Displacement=AB+BC-AC
Applicant's home
A
B
Applicant's workplace
1 mile
Applicant matched with candidates whose workplaces are within 1 mile of applicant's and who also satisfy other matching criteria.

Figure 3. Vector Search Method in Denver, Colorado, Carpool Matching Program

file with identical work schedules. Documentation has not been prepared, but operation is apparently straightforward as about 20 other organizations use the programs.

Conversion to regional matching - In present practice, matching is being done on a destination basis. As can be seen from the preceding description, the program can be used without change for the regional matching when it is underway. The radii of the destination circle would be adjusted to suit the data base; longer radii are needed for fewer candidates. While some employers now use 0.2 mile for the destination search, it is planned to use 1.0 mile for the region.

When the regional matching service is underway, the existing employer data will be combined with new applications from the general public. The version of the program designed for Min-Comp to use for the regional matching has a built-in security feature which is intended to prevent anyone from gaining access to another employer's files. Printouts will include the home-to-home and work-to-work distances and the work telephone number of potential carpool partners, but will not include home addresses. Reportedly, with this feature no firms have so far objected to pooling their data with the regional data. (Of course, there has as yet been no reason to object inasmuch as the regional system is not yet operational; the true test will occur when the regional system operation begins.)

The overall process actually uses three programs, including one for maintenance and corrections, and another which produces density matrices which can be used for such purposes as planning transit service.[23]

Automatic Data Processing/Westinghouse program - Several Westinghouse Broadcasting Co. radio or television stations are operating regional carpool matching systems. Some of these stations (including WIND in Chicago and KDKA in Pittsburgh, both discussed in Section III) are using the firm of Automatic Data Processing, Inc. (ADP) to perform the matching service. ADP has written their own matching program for this purpose. This program is available to any organization which needs it, but is sparsely documented.

The matching process is designed for regional systems, and uses a grid system. The origins and destinations are both identified according to the alpha-numeric designations of the grid cells in which they are located. This geo-coding is performed by the applicant. The program can, however, use other types of origin codes such as traffic zones or zip codes. There is no searching of adjacent zones if zip codes are used (as in Chicago for origin codes), but with a grid system adjacent cells are searched for additional matches (as with the destination coding for Chicago).

The program prepares output only for applicants not previously processed, but retains previous data for making matches with new applicants. Processing time is a function of the number in the data base, the number of new applicants, and computer model, but a typical run for new additions to a data base with a few thousand applicants would require 15 to 30 minutes.

The program is written in COBOL and has been successfully run on Honeywell 1250 and 2200 and IBM 360 computers. With the Honeywell machines, the program used 32K core capacity and four tapes. With the IBM machines, the program used 64K core capacity and one disc and three tapes.[17]

Other computer matching programs - The programs described here are those judged to be of greatest interest to organizations who want to establish regional carpool systems. Many other programs exist, and some of these were mentioned in Section III of this report. Some additional data on the programs available are in Reference 29, prepared for FHWA.

OBSERVATIONS AND SUMMARY

General

Of the numerous computer programs available for matching prospective carpool candidates, only a small number have been well documented, widely distributed, and used for substantial amounts of data. Even among these few there is insufficient experience to enable a conclusion of which program is best (if any is). Furthermore, there are some additional programs which are not well known but may offer promise for use in regional carpool systems.

Based upon the review undertaken for this report, some tentative conclusions and recommendations can be offered. Above all, however, it is important to bear in mind that some of the major computer programs are being revised or refined, documentation is becoming available, and experience is accumulating rapidly, so these conclusions could be shortly rendered invalid by changing circumstances.

Tentative Conclusions On Matching Software

1. The central purpose of the matching program is to identify potential carpool partners to an applicant for the matching service. The program thus should identify a reasonable number of persons whose transportation route and schedule are nearly the same as the applicant's. The program need not supply more than enough names to provide the applicant a modest amount of choice among his carpool partners. Theoretically, the program should attempt to provide a list of the best (i.e., most convenient) partners. Inasmuch as this is actually impossible, the program should provide enough names that the best choices are probably among them.

2. To achieve the goal stated in (1) above probably requires a multi-step matching process; that is, it is probably necessary to use a program which searches for matches over a variable area around the origin and/or destination, or which searches for matches along the applicant's route.

3. The size of the geographical area searched for matches should be related to the density of possible matches. Consequently, coding should allow greater detail in densely developed areas such as central business districts than in residential areas. This in turn implies that with grid systems the grid cells need to be smaller in employment centers than in residential areas, or that non-grid systems should be used in employment centers.

4. Because of the need for a multi-step matching process, the programs now in use which seem likely to be most effective are those which use either a grid or an x/y coordinate system for coding of origins.

5. Matching criteria other than origin, destination, and work schedule are probably of only minor importance and may be difficult to implement. If personal preference data is desired it seems more practical to merely list these data on the output forms for the use of the applicant, rather than actually forming matches on it.

6. Steps should be taken to safeguard the privacy of data which is not essential to disclose in the output. Furthermore, these safeguards should be clearly identified to alleviate any fears and to preclude complaints arising from erroneous impressions. Specifically, home addresses and telephone numbers should not be disclosed by regional carpool systems if alternatives are available. Alternatively, the applicant should be allowed to specify what contact address or telephone number he wishes to release.

7. Any program should allow for readily revising the carpool data, either manually through master lists or automatically using the computer. The maintenance service should be publicized. Lack of this feature is a potential major drawback of most broadcaster-operated systems.

8. For destination-based matching, or for the destination-based portion of a combination system, several programs are adequate. The FHWA, Census, and Burroughs programs are all operational, documented, and widely available. Choice among these must at the present time be made on the bases of computer capability, preference, and circumstances.

9. For region-wide matching, the suitability of present programs is less clear, in particular because so little experience has accumulated. At the present time the Denver program, with both cluster and vector search methods, appears to be very promising, but is not yet proven for regional matching and is not documented. The Burroughs program appears to be second best, with its version of vector search, but apparently also has not been proven for region-wide service. The Census Bureau program is complex and has proven difficult to implement but may ultimately be very workable, especially in cities with current DIME files. The FHWA program is limited in usefulness for regional matching because of its grid system and one-by-one destination matching. All other regional programs surveyed for this report, chiefly those used by broadcasters, are either too primitive in their matching (most use one-step geographic matching) or are not well enough developed to recommend.

10. What will be needed before final conclusions can be drawn about any carpool matching program is information on the long-term effectiveness of such programs for encouraging the formation and use of carpools, not just information on data base size, matching rates, computational cost, or other characteristics of the program itself.

11. Any matching system should be suited to the circumstances where it will be used. In spite of the above comments, there may be areas where, for example, single-step matching based upon zip codes is effective, if not perfectly satisfactory. The matching process itself is not carpooling, and only serves it. Selection of a program should reflect the local needs, abilities, and preferences of the matching system operator and the public.

SECTION V

ORGANIZATION OF CARPOOL SYSTEMS

GENERAL

Some very helpful literature has previously been published on the subject of how to organize an effective carpool program. The reader is directed to references 9, 37, and 39 in particular. This section will summarize the results of the survey for this report, with an emphasis on regional systems.

EXPERIENCE WITH ORGANIZING CARPOOL SYSTEMS

Carpool matching systems have been operated by several types of organizations. Experience with three of these types will be summarized.

Broadcasting Station Systems

Two of the carpooling systems investigated for this report which have the largest data base are operated by broadcasting stations. These two, operated by WBBM in Chicago and WBZ in Boston, were described in Section III. This section will review the organization aspects of their carpool campaigns.

WBBM, Chicago - The WBBM carpool system is entirely destination-based, and consequently the employers are the key to its operation. The organization is simple in the sense that it consists only of an arrangement between WBBM and each of the employers. The radio station provides the matching service, including keypunching, computer matching, and the survey forms. The employer provides the distribution and collection of forms and any incentives he may wish to use to encourage carpooling.

The incentive for the radio station is apparently the public relations exposure, among major employers in particular. WBBM is an all-news station and thus its audience (and its advertisers) are apt to include people in the management of such firms, perhaps more so than stations (such as WIND in Chicago) which appeal to a younger audience.

The incentives to the employers are the no-cost matching service and the public relations impact of receiving mention on the air by WBBM as a participating company.

WBBM does not prescribe how the employer should distribute, promote, or collect the carpool survey, but the survey form is designed to be inserted in pay envelopes.

This organizational structure is simple and apparently effective in the sense that over 100 employers with over 100,000 employees have signed up for the service. It is too early to determine, however, how effective the organization will be at attracting applicants. WBBM estimates that 10 percent of employees will participate.[11]

WBZ, Boston - The WBZ carpool system is probably the oldest regional system. It is nearly the opposite of the WBBM system. WBZ shares responsibility for overall organization with the ALA Auto and Travel Club. Solicitation of applicants is directed largely at the general public, although some promotion has been directed at employers as well.

Formally, WBZ and ALA have responsibilities clearly defined by an agreement between them. In essence, WBZ contributes promotion and materials, and ALA contributes data processing and clerical work. This arrangement seems workable and is apparently amenable to the participants, but the commitment expires in August 1974 (although it could be extended).

The WBZ system has processed approximately 15,000 applications. This is more than most regional systems, so in that sense the organization seems effective. On the other hand, 15,000 applicants is a very small fraction of the Boston area commuting population. Based upon the experience in other cities with destination-based systems, and based upon the comments from Boston-area employers, the WBZ-ALA system would have drawn more applicants if more employers had strongly supported the program, for example by providing incentives and by collecting applications. Large employers have been wary of the lack of privacy protection and for this and other reasons have preferred to operate their own systems.[15] (See the discussion which begins on page 18.)

Summary - Broadcasting stations may be extremely useful in promoting and publicizing carpooling and carpool matching systems. It is questionable whether a broadcaster can enlist enough public support to operate an effective system on its own. Employer support appears to be important to attracting a good data base. Furthermore, broadcasters involved in present programs have planned only one-year commitments; it appears unlikely that a broadcaster will wish to carry the central role in a carpool system for more than a year or two, at least without compensation.

Systems Operated By Other Elements Of The Private Sector

A few systems involve the private sector without broadcasters playing a major role. The only system of this type investigated for the present report is the Denver system, which is at present being operated by a business organization and an auto club, with technical support from a high school. This organization has been effective so far but the region-wide system is not yet in operation. In addition, the present plan is to turn over the major role to the regional council of governments if funds can be obtained; this may be indicative of the trend for such organizations, because of factors such as the cost involved. In Denver, for example, the equivalent of two or three full-time people have been committed to this effort, at no charge to the employers receiving the matching service.[23]

Systems Operated By Government Agencies

In Dallas, Knoxville, Washington, D.C., and in several cities in Connecticut and California, government agencies are involved in or are the chief operators of carpool matching systems. Many more government agencies will become involved in the near future, particularly as a result of the FHWA efforts to promote carpool systems by providing Federal funds.

In Dallas and Fort Worth the organization is characterized by the joint efforts of the two cities. Responsibility for the work is also shared with the employer (see Section III). Dallas reports that their system suffers because the Chamber of Commerce committed itself to support of the systems operated by two radio stations.[25]

In Knoxville the organization is led by a committee representing government and commerce, which appears to have been effective inasmuch as at least half the employers are participating. The Knoxville organization has the personal support of the Mayor and has included the transit authority for coordination of bus and carpool service.[30]

In Connecticut, California, and Washington, D.C., the government agencies are supplying mostly technical advice and data processing. Overall organizations include the business sector and broadcasters.

In Connecticut, for example, several different organizational structures are used in the several cities involved. The chief characteristic of these organizations seems to be an ad hoc coordination of the private and public sectors with the state carrying the burden of the long-term commitment to maintaining the data base. It may be worthwhile noting that the latest of these three agencies to become involved, California, is planning to charge for their services rather than to donate them.

Summary Of Experience

Most carpool systems are being operated by ad hoc organizations consisting of one or more private sector elements and one or more government agencies. Several types of structures are in use and are effective.

The most effective systems have had the strong support of employers, especially major employers. This support includes active support and promotion within the firm among the employees. Broadcasting stations have been effective at promoting carpooling and carpool systems, but it is questionable whether they can carry the chief responsibility for operating a regional system, particularly because that role requires a long-term commitment which broadcasters may wish to avoid.

Government agencies are becoming involved in carpool systems at a rapid rate as a result of the provision of Federal funds. Because government agencies are suited to long-term responsibility of the type involved with maintenance of carpool systems, it seems clear that regional systems should and probably will rely on such agencies for leadership and data processing.

Regional matching systems are most likely to be effective where major employers strongly support the system and encourage the use of carpool matching and carpooling itself among their employees. For this reason, it may be that a dual approach will be needed. Some employers may be reluctant for any of several reasons to pool their data with those of other employers. In such a case it may be well to provide good-quality destination-based matching service to these employers, while at the same time providing region-wide matching service for cooperating large firms, smaller firms who couldn't do their own matching, and the general public. This dual approach may not maximize the number of applicants in the regional data base, but it will maximize the number of applicants in matching systems. The probable necessity for this dual approach is one reason there is a need for a government agency to be the chief administrator of matching systems, in order to coordinate the two approaches and provide technical support of not just one but two systems.

FUNCTIONS AND COSTS

Responsibilities In Regional* Systems

Most initial carpooling system efforts have been done as a public service by the private sector. As Federal funds become available and as the numbers of systems and applicants grow, the burden of costs will probably shift to government agencies.

The private sector should still be enlisted to support the carpool system. Some ways this can be done are proposed in Reference 9. For regional systems, a brief outline of responsibilities is suggested below.

Leadership - Especially at the beginning of a system and while trying to develop the data base, an ad hoc coordinating committee should provide overall direction. Membership should include business leaders, government agencies, and key employers.

---

*Carpool systems serving a metropolitan region, whether defined as regional or combination systems.

Promotion - Broadcasters should be enlisted to promote the system, especially in the beginning phases. Most will probably undertake this at no cost to the public. During long-term system operation, periodic public service announcements will no doubt be carried as part of the station's regular programming. Promotion to employers should be through the Chamber of Commerce, downtown business coalitions, or similar membership groups. (See also Section VI.)

Data Processing - With the dual approach recommended here, it is best that a government agency retain and process the data. Private sector elements may be a viable second choice, however, particularly where such systems have been begun by private groups. In any event, no firm should be prevented from doing its own. If employers wish to operate their own systems, technical support should be provided by the regional system management to the employers so that the employers' internal programs will be effective.

Costs

Costs have not been extensively surveyed for this report, but from the sources reviewed several useful indicators of the costs of administering a system can be presented here.

Promotion Costs - Major promotion on radio and television could probably be donated by broadcasters, much as they have donated time to present efforts. Newspaper advertisements may even be donated, although there is less precedent for this. News coverage in both the press and other media will of course cost nothing. Paper promotion tools such as bumper stickers, brochures, and flyers are available from the Highway Users Federation for a few cents apiece. Similar publicity materials custom-prepared for each system could be produced in-house at employers at minimal expense.

Data Processing Costs - The Denver system has arranged for data processing at a price of 15 cents per person initially and 10 cents per person for maintenance changes. When combined with geo-coding (by hand), and other clerical and administration costs, Downtown Denver estimates the cost to be $59.50 for 100 employees, or 60 cents each. In California, the state now estimates the charge for the total package of initial processing (instructions, maps, keypunching, data processing) to be 50 cents per person, with a charge of 25 cents per person for revisions (maintenance).

Distribution Costs - Mailing questionnaires and computer output would cost 20 cents per person for postage alone unless collection and distribution were handled through the employers. The latter method is less expensive, less complicated, and more effective.

Administration - Judging from systems now in operation, only a small number of people are required for a full-scale system. This may be judged from the fact that the systems now being run by the private sector have all been done without hiring additional staff for promotion or data processing.

Denver has submitted a proposal for funding an interim carpool office for five months until the FHWA-sponsored COG office is in operation. The total cost of this office for five months is estimated to be $32,500, which includes three full-time and one half-time staff members and clerical expenses. (Denver's metropolitan area had a 1970 population of approximately 1.2 million.)

The city of Dallas estimated that approximately $170,000 would be the total cost of a two-year carpool-buspool campaign. This cost includes data processing, printing, publicity, and so on. Maintenance of the system was estimated to cost $20,000 per year. (Dallas had a 1970 metropolitan area population of 1.5 million.)

The California DOT carpool program, which involves statewide matching service plus administration of promotion and incentives, is estimated by the state to require approximately 26 man-years of effort for the CDOT effort at the headquarters level and in the district offices. (California had a statewide population of 20.0 million in 1970.)

Costs Of Incentives - The costs of explicitly provided incentives will not be estimated here, owing to their wide variability.

Total Costs - Based upon the estimates above, it can be estimated that a regional carpool matching system, organized as described here, will cost on the order of 10 to 50 cents per person to initiate, and only a few cents per person per year to maintain, exclusive of major promotion and incentives.

SECTION VI

MARKETING

GENERAL

This section of the report will examine techniques for marketing both the concept of carpooling and specific carpool matching programs. As in past sections the emphasis here will be on the results of the investigations undertaken for this report. Planners of carpool systems should also refer to previous literature on marketing carpooling; the literature from the Highway User's Federation (HUFSAM) is particularly helpful (Reference 37).

As used in this Section, "marketing" includes four concepts: promotion, price, place, and product.

Promotion is the visible aspect of marketing, including advertising and public relations. This Section will emphasize promotion because the public needs not only to be informed about carpooling but also must be persuaded to form carpools, much as consumers are persuaded to desire other products or services. Promotion includes selling the carpool concept to employers and community leaders, as well.

Price involves two elements with respect to carpooling. First, there is the price to the applicant for the matching service. In this sense price also involves the effort or inconvenience associated with the application. Second, there is the price of joining a carpool. This price may be the inconvenience of sharing rides. In return, the carpooler receives certain benefits.

Place is the idea of how, where, and from whom to obtain the service being marketed. In this case, one function of marketing is to inform people of who runs the carpool system and how to participate.

Product is both carpooling and the carpool matching service (actually, both are services rather than products). The marketing, especially promotion, must demonstrate the desirable features of the product so that people want it. Defining what the product (or service) actually is directly affects its appeal and thus is part of the marketing process.

Carpooling must be marketed, not merely "publicized," because people must be encouraged to change their habits in order to increase carpooling. Successful carpool campaigns should include these four aspects of marketing in the initial planning in order to both develop a good product and convince the public of its value.

The need to actually persuade people to form carpools, rather than merely inform them of the carpool system, is supported by the findings of a behavioral research study performed for the California Department of Transportation (CalTrans) and reported in Reference 33. In that study, it was found that 64 percent of surveyed drivers in Los Angeles could be termed "hard-core non-poolers," or people who would be difficult to motivate to form carpools and would require negative incentives, such as government regulations to restrict parking, to achieve increases in carpooling. This study found that the remaining minority of the population would form carpools if adequately motivated. Motivation would include explicit incentives, discussed in Section VII, but also would include emotional desire, social considerations (peer approval, e.g.), and an understanding of the personal benefits of carpooling. Marketing can be seen as a process by which one can influence the perceived desirability of a product, by informing, cajoling, and persuading. (Actually part of the marketing may be done for the local system by outside sources. The U.S. Department of Transportation and Exxon, at least, have been widely advertising the merits of carpooling, which may help to improve the public image of carpools.)

MARKETING OF PRESENT CARPOOL SYSTEMS

Regional Systems

Existing carpool matching systems have had varying amounts of marketing. The broadcaster-operated regional carpool systems have been characterized by substantial promotion or publicity. The promotional campaigns for several recent systems were described in Section III. Promotion included newspaper advertisements, billboards, special major television programs, automobile races during rush hour, and frequent announcements (commercials) throughout the daily radio or television broadcasts. Large quantities of questionnaires were delivered to bulk distribution centers such as shopping centers, highway toll booths, and restaurants. In the Boston area, for example, it would seem likely that nearly every commuter had heard of the WBZ-ALA Commuter Computer by March, 1974. The Boston plan attracted attention as news, also, in local newspapers, national magazines, and even in the scientific press.[34]

Besides these promotional efforts directed at the general public, other promotional techniques have been used to attract employers to participate. Industrial groups and Chambers of Commerce have supported the existing carpool systems by official endorsements, editorial support in organization journals, special publicity letters and brochures mailed to member firms, and by provision of questionnaires and other direct support.

Publicity of these regional systems has had good results in the sense that the general public has become aware of the system and many thousands of application forms have been distributed; on the other hand, applications have been returned at a low rate. Another effect of these regional marketing efforts no doubt has been a more widespread understanding of the benefits of carpooling. It is possible that carpools have been formed as a result of these marketing efforts even without the use of the matching systems; certainly people are talking and thinking about carpooling to a greater degree than ever before (or, at least, since World War II).

Destination-Based Systems

Destination-based systems operated within just one firm have certainly received less external publicity than the regional systems. But such systems are often heavily marketed within the organization. Typically, the carpool effort would begin with a letter from a chief executive officer to all employees, then be followed up by supervisors distributing and collecting questionnaires. Other devices have included displays in the company cafeteria, listings of carpools and feature stories on carpooling in company newspapers, bulletin board posters, and public address announcements. In the firms whose systems were reviewed for this project and in other firms whose programs are described in the literature, such techniques have resulted in response rates which have varied widely but have been as high as 50 percent or more of employees requesting the matching service.

Combination Systems

Present combination systems have been promoted both externally (i.e., publicly) and internally (i.e., within the affected firms.) In effect such systems have been promoted as if they were separate destination-based systems but with public support.

Recommended Approach

For the dual approach tentatively recommended in Section III, namely combination systems with both destination-based and regional matching services, both public and internal promotion appear to be needed. Aspects of these promotion methods will be discussed further in the ensuing portions of this Section.

MARKETING METHODS FOR CARPOOL SYSTEMS

Appealing To Employers

For the success of any carpool system it is imperative that employers support the system, so it is important to consider them explicitly in the marketing plan. Perhaps the most important way to do this is to include the employers in the planning of the overall system. In particular, support should be solicited from industry and commerce membership organizations and perhaps labor leaders as well. These organizations in several cities have undertaken substantial public relations campaigns among their member firms in support of carpool systems.

One reason industry groups should be included is that they know who the key people are in the major employers. They may also have ready access to otherwise confidential data on numbers of employees. Obviously it would be easier to plan a carpool campaign with the assistance of such groups than with their indifference or opposition.

In many cities, such industry or commerce membership organizations probably have been among those who took an active part in hearings on Transportation Control Plans (TCP's) where necessary to comply with the Clean Air Act. Such groups may have opposed measures which would reduce mobility or reduced parking supply. Because widespread carpooling can reduce the amount of other travel restrictions necessary for a TCP, business leaders should be shown how their support of carpooling systems can prevent the necessity of other more stringent travel controls. This perspective is one reason industry groups have widely promoted carpooling in Boston, e.g.

Employers should be shown several benefits to them of carpooling among their employees.

One approach used by the Associated Industries of Massachusetts (A.I.M.) in their newsletter to members was to emphasize the point that strong support of carpooling could eliminate or at least reduce their role in TCP reductions. A.I.M. suggested that more severe government travel restrictions would be imposed if carpooling did not occur voluntarily, and that public relations would be adversely affected. Other advantages of carpools (e.g., cost savings to commuters) were also publicized.

To help encourage companies to promote carpooling among their employees, A.I.M. acted as a distributor for the WBZ-ALA carpool survey forms. A.I.M. printed them, charging only costs, and even arranged for special company messages on the questionnaires. This was a useful technique of personalizing the WBZ-ALA campaign for the specific firm. A.I.M. also publicized the HUFSAM seminars on carpooling, and organized meetings among the system operators, employers, civic leaders, and government officials.[15]

In its literature on carpooling, Burroughs Corporation emphasizes the value of carpool systems for employee relations and public relations (as well as the technical aspects of reduction in costs).[39] Many firms are very conscious of their community relations, particularly if their employees are largely from the inner city or from lower-income groups. The public relations aspect of company carpool operations has been a basic incentive for the employers participating in the WBBM "Ride Together/Drive Together" system in Chicago, for example. Firms receive mention on the air and in press releases, and consequently obtain free favorable publicity.[11] In this connection, system organizers may want to allow a few firms to use the system on a "trial basis," and arrange for good press coverage with favorable publicity for the firms. This will help entice additional participants.

The HUFSAM literature identifies several reasons which can motivate employers to participate in carpool systems. Besides the general public relations, employee relations, and energy-savings aspects mentioned elsewhere, other incentives include:

1. Plant facility expenses. Fewer cars in use for commuting reduce the cost of providing and maintaining parking facilities. (Parking spaces can cost up to $5000 each.)
2. Neighborhood relations. Carpooling can reduce employee parking and traffic congestion in areas adjacent to the employer's facility.[37]

HUFSAM also publishes a number of clear, useful brochures and advertising devices which can be helpful for communicating with employers (or employees). The HUFSAM literature emphasizes the economic benefits of carpooling (and buses) and shows examples of successful programs.

An important aspect of marketing carpool systems to employers would in most cases be the advantage of receiving free or low-cost matching service. Employers may find the master lists most matching programs produce useful for giving advice on transit or for advice to help a temporary employee, new employee, or stranded employee surmount special travel problems. If a central agency handles data processing, the employer should be shown the advantage of not having to design and operate his own matching system with the attendant costs and problems. This argument is probably most useful for the medium-size employer who would need more than manual matching but would find it difficult to undertake his own computerized system. (On the other hand, employers who can afford the effort may support it more actively if they contribute enough work to feel it is "their" program.)

Appealing To Employees

Individual employees may be a more difficult audience for marketing of carpooling because of the diverse personalities, situations, and preferences involved. The problem is twofold: (1) the actual benefits vary among people, and (2) perhaps more important, the perceived benefits vary considerably. Planning for carpool services should thus consider the idea that no one incentive or marketing approach will suffice for all potential carpoolers.

Another point to bear in mind is that people will be prepared to raise numerous objections to carpooling. There are disadvantages, and these should be recognized. But the marketing campaign should anticipate the drawbacks by emphasizing the compensating benefits. (This is part of "defining the product.")

The employer can make his carpooling system participation very personalized. By doing so he makes the entire process more appealing. For medium-size employers, or those which have only modest numbers of people applying for carpool matching at any given time, it may be possible to provide personal contact between the employer's carpool staff and each applicant employee. This has been the approach in many firms performing their own matching, such as the five Boston-area employers discussed in Section III.

One of the most universally useful arguments in favor of carpooling is that of economics-riding together saves money for the commuters. Other less tangible benefits such as benefits to the environment would probably persuade fewer people than would the simple savings in travel costs. Unfortunately perhaps, most people do not perceive the true total cost of operating an automobile.[33] Consequently, the economic benefit of carpooling is most easily demonstrated for the longer trips. The HUFSAM literature provides some good examples of cost savings.

In this time of recent (and possibly future) gasoline shortages, another motivating element may be convenience. Riding in a carpool reduces the amount of time waiting in queues for gasoline, reduces the anxiety about running out of fuel and, if gas-stops in rush hour can be eliminated, it may save on travel time. (A possible arrangement to capitalize on this feature of carpooling is to have spouses fill the gas tanks during off-peak hours when queues are shorter, thereby totally eliminating the frantic search for fuel while travelling to and from work.)

Explicitly provided incentives such as preferential parking for carpools (discussed in Section VII) should be well-publicized. Special contests and games with one-time incentive prizes have proven to be popular parts of campaigns to sign up carpoolers (but be wary of duplicate applications).

Several employers contacted during this study emphasized the idea of showing that the company (or agency) is really behind the carpool system, by the use of techniques such as letters from the president requesting participation, personal appearances by upper management at kickoff publicity meetings, publicity techniques such as showing photographs of the managers arriving in their carpools (be sure they really do take it seriously and sign up), use of former executive parking for vanpools or carpools, providing incentives, and similar techniques. Use of normal communication channels is helpful-carry items in the company newsletter, on bulletin boards, over public address systems. One company contacted has a pre-recorded message by a senior officer which can be heard by any employee by dialing an advertised number on company telephones. The message explained the status of carpooling and extolled its virtues.

Employer campaigns should be credible, substantial in extent and duration, and well planned. An excellent overall approach mentioned several times by those contacted in this study was to conduct a carpool campaign in a manner similar to the way United Fund or other major charity drives are carried out, with team captains with specific responsibilities for obtaining results, inter-departmental competition for response, advertised results, and generally a highly-organized, fully-supported effort.

Another technique suggested by the radio station campaigns is to make carpooling "fun" through the use of light-hearted advertising, limerick contests, prizes for signing up your friends, perhaps pretty "carpool-girls" touring the cafeteria at lunchtime to remind people to return their questionnaires.

Appealing To The General Public

Obtaining support and participation from the general public (i.e., from the people who are not reached by the employers' campaigns in a regional or combination system) is most difficult of all. The isolated commuter is difficult to appeal to in part because he may not readily identify with the carpool system promoter. This is one reason the organization operating the system should be broad-based and well-organized.

Many of the techniques and concepts discussed above under "Appealing To Employees" will also apply to the general public. (For that matter, some of the discussion in this sub-section may well apply to employer campaigns for their employees.)

The exact nature of the promotion is, first of all, not capable of rigid definition. No system is "best." Second, the system must suit the circumstances. In one city the regional promotion may need to appeal to over half the region's employees, and these may be employed throughout the area (Boston, e.g.). In another city the employees not covered by employer programs may be only a fraction of total employment, and may be concentrated in a few employment centers such as a small central business district (Knoxville, e.g.). Marketing must reflect the local fuel supply situation, the local air quality needs, the local geography. Only general guides can be given here.

Commitment is important. Repeatedly throughout this study, carpool system organizers have commented on the need for commitment on the part of the system operators. Some said it has been more work than was expected. Those organizing and promoting the system must be committed to a long, substantial effort, not just a momentary flurry of activity. This is one reason for insuring that a government agency with a long-term responsibility is at least part of the leadership organization.

Leadership should be both professional and popular. By this it is meant that the staff running the operation should be capable and effective, but there should be an externally visible popular leader or leadership group. The mayor of a city or governor of a state could appoint a prominent civic leader as general chairman, for example, much in the way he would appoint a task force to tackle a community problem or would appoint a leader for the United Fund campaign. Again, the United Fund type of organization is a good model for how a carpool service can achieve popular support, especially at the beginning. Support from all quarters is helpful: labor leaders, politicians, environmental groups, community associations.

Media involvement is essential. In Dallas, for example, the lack of broadcaster support because of competing carpool systems was reported to have hindered development of the campaign.[25] There is a valid issue here of how to best arrange for good media coverage, however. Some media people advocate allowing all media (e.g., all radio stations) to simultaneously promote one carpool system. Others, however, contend this is counterproductive. It is argued that if only one broadcaster (who may actually be one AM, one FM, and one television outlet) has the rights to the publicity for the campaign he will carry it out more vigorously and will be more likely to live up to his commitment. Under this argument, simultaneous support by all stations would probably quickly degenerate to a few perfunctory public service announcements each week, mixed into the programming with all the other public service functions stations are asked to perform. Certainly the use of a single broadcaster could add to the flavor of a promotional campaign and the degree of specific identification with it. This issue cannot be resolved here but is worthy of further consideration in planning specific promotions.

Professional advice should always be sought. As was mentioned earlier, a broad-based committee or board should be the leadership organization. Before even forming the committee, the rough system plans should be discussed with community leaders so that even the very beginnings of the system and its structure are assembled with the advice of the community leaders who ultimately must support it. People from broadcasting or newspaper organizations should be asked for their advice on how to market the system, and perhaps one should be chosen as an honorary vice-chairman to help design the details of promotion.

Objectives of the promotion include:

1. Inform the public of what is going on, how to participate, and other technical aspects of the operation. These should include information on security and privacy, maintenance, and responsibility.
2. Demonstrate the benefits of participating, both for individuals and the community.
3. Persuade people to join up.

The content of the promotion should thus reflect all three of these elements. It is particularly important to accurately and completely inform people of the procedures, advise them of their responsibilities, explain the idea that carpooling is voluntary, and explain the idea that people can change their mind and either sign up later or not participate when he receives his list (i.e., the system is flexible).

Throughout the marketing process it may be well to bear in mind the inherent limitations of the carpool system's appeal. The Los Angeles study of attitudes toward carpooling showed that the majority of people who now drive to work are "hard-core" lone drivers. Strong incentives or disincentives might attract some of them to carpools, but unwillingly.

Reportedly such people will not perceive the advantages to them of carpools. The report suggests that it is most effective to market carpooling to those who are considered "potential carpoolers." That study also concluded that, of several motivation techniques available to encourage carpooling, a carpool matching service would be the most effective for the 24 percent* of the sample deemed to be potential carpoolers. Several psychological factors involved with carpooling are identified in the report.[33] On this thesis, the marketing approach should emphasize the factors shown to be of interest specifically to people who are potential carpoolers, such as convenience, economic savings, and air pollution and fuel conservation benefits, rather than to try to persuade the "hard core" non-poolers to join. This theory suggests it is not cost-effective to try to convert the "hard-core non-pooler."

Administration

Charges - One question is: Who pays the bill? It seems imperative that individual commuters not be asked to pay the cost of the matching service, for they would probably be deterred from applying for the matching service. The FHWA is now providing funds for operating carpool systems, and several cities have applied for this aid. Unfortunately, however, this is not additional money but instead is from a fixed maximum amount of urban traffic improvements funds. Some states may choose to use all these funds for projects other than carpooling, thus necessitating other (non-Federal) sources for carpool system operation.

The private sector may be able to provide financial support. Employers will probably be willing to contribute effort or funds where large numbers of employers are involved so that costs are widely distributed.

---

*The exact results of that study, performed in Los Angeles, may not apply to areas with different travel habits and attitudes.

As noted elsewhere, however, it is likely that government agencies will play a key role in most regional or combination systems. Consequently, it is also likely that the government will generally be required to provide much of the resources needed for operating the system.

Distribution and Collection - An effective system will minimize the effort required of applicants. Questionnaires should be distributed through employers wherever possible. Supplementary distribution should include the places people visit frequently-grocery stores, shopping centers, and similar locations. Ideally, questionnaires should be available with just a telephone call, and postage should be prepaid by the system operator. Minimizing effort will maximize participation.

Replies from the matching service should be prompt. Frequent computer runs will be rewarded by better public response. (Some systems now involve a discouraging lag of several weeks from the time questionnaires are requested until a match list is received.) Distribution through employers should be encouraged, and firms should consider giving an employee time on the job to contact fellow employees on his match list.

Questionnaires - Format of the matching questionnaires or application forms will be determined by the data required. Simplicity is to be encouraged. Small, readily understood forms would appear to be best, and would thus be suitable for easily stuffing into pay envelopes or postcard mailing. Smaller forms will be less expensive to print in newspapers. One-piece self-addressed forms would add to convenience. If larger forms are used, an advantage could be the use of one side for endorsements, explanations, or letters from company management. Existing systems use forms which run the gamut from simple to complex. Among the smallest and simplest is that for WBBM in Chicago; among the most complex is the four-page form for Knoxville. All forms should be pre-tested in trial surveys (as should the entire marketing approach).

An associated concern is a map for those systems which involve the use of a grid. If applicants themselves identify their own grid cells, errors will result unless the maps are very clear and logical. This problem may be more severe in some areas because of the particular geography involved. Where maps are to be used, extensive pre-testing is recommended in order to insure the adequacy of the map.

SUMMARY

Carpooling and carpool matching services must both be actively marketed rather than merely publicized, in order to overcome widespread disinterest, objections, and apprehensions about carpools among the commuting public. The marketing effort should both inform and persuade, and include thoughtful determinations of what the product is and what the best promotional techniques are in the circumstances.

Present carpool systems have been marketed in a variety of ways. Regional, broadcaster-operated systems have been characterized by substantial, highly visible, colorful promotion. Many destination-based systems have been strongly promoted within the organization served, even if there has been little externally visible promotion. Combination systems have involved both internal and external promotion.

It is recommended that promotion be directed towards both the general public and through employers at employees. It is particularly important to obtain well-known top leadership and broadly-based support from community and business groups. The management organization must have a firm, long-term commitment. Industry and business organizations should be enlisted to aid in marketing carpooling to employers. Special campaigns for employers should emphasize the advantages to them of promoting carpooling among employees. Overall operation could effectively be patterned after major United Fund-type charity drives.

Marketing to the employees and the general public should emphasize the personal advantages to the individual of carpooling. As part of this, it should be clear to the public that employer management and community leaders support the system.

Community involvement in planning the system and in planning the promotion of the system will be worthwhile, and should involve professional advice from experienced marketing forces such as broadcasters.

The promotion should recognize that not everyone is a potential carpooler and should concentrate on the segment of the commuting public likely to become carpoolers with adequate motivation. To encourage participation, effort and cost to the commuter should be minimized. Promotion and data collection techniques should be designed with local conditions in mind and pre-tested before widely used.

SECTION VII

INCENTIVES AND DISINCENTIVES

GENERAL

This section will discuss incentives for carpooling. In this report, incentives are actions takent to explicitly encourage carpooling. Personal benefits of carpooling, such as reduced costs to the commuter, are not explicitly provided and were discussed in Section II. (These benefits must, however, be emphasized in promotional efforts.) Other detailed discussions of incentives are listed in the bibliography.

Planned incentives alter one or more of the following characteristics of travel:

1. Travel cost
2. Travel time
3. Convenience
4. Intangible and nontravel-related factors.[40]

These are the elements which a person either explicitly or implicitly considers in making his travel decision. In a multi-modal situation, the communter uses these considerations to decide whether to drive, ride the train, take a bus, or whatever. Many commuters do not have a true mode choice, however. Such people more or less must travel by car because of where their home or job is located or because of their work schedule. One difficulty with trying to encourage carpooling is that many auto commuters are in a well-established habit of driving alone, and may never have seriously considered forming or joining a carpool. The marketing program described in Section VI is intended to bring the carpooling choice to the commuter's attention and influence his decision; incentives can provide added weight to the argument in favor of carpooling by providing benefits to the carpooler above and beyond those inherently involved in carpooling.

The role of incentives in encouraging the use of carpools is at this point an arguable one. Some experts contend they are essential while others consider a good matching system is the key to increased carpooling. During the course of this study it became clear that carpool systems were attracting greatly increased interest because of the fuel shortages in early 1974, particularly in cities (San Francisco, e.g.) where shortages were especially acute. This qualitatively shows the effect of disincentives. Unfortunately, there are only a few studies which show the quantitative effect of incentives on carpooling.

One such study, Reference 33, has been mentioned earlier in this report. As part of the work for that report, an evaluation was made of how receptive people were to a number of proposed incentives. Of those people who were at least somewhat interested in carpools, the following percentages were stated to be likely to carpool if the proposed incentives were provided.

Proposed Incentive	Percentage of People Who Would be Likely to Carpool
Carpool parking lots near freeways	70%
Use of company cars for carpools	63%
Gas tax rebates	61%
Free or lower parking fees	60%
Reserved freeway lanes	57%
Preferential (more convenient) parking	57%

Note that this survey was taken in the Los Angeles area, and that most respondents use low-cost or free parking facilities near their employment sites at the present time. Also note that these are postulated conditions; people sometimes behave differently from the way they expect to. Also, the survey was taken in the Fall of 1972, before gasoline became less available and more expensive.

Most actual experience with incentives to carpooling has been with destination-based carpool systems or with isolated public incentives. From a review of the literature and from the review of carpool systems conducted for this report, the most commonly used carpool incentive is preferential parking. Most such cases involve a restricted supply of parking, however, so that vehicle occupancy would be expected to be higher than average even without explicit carpool preference. Several examples are cited in the literature of average vehicle occupancies up to two or three times the U.S. average where carpools are given preference.

Other types of incentives have also provided increases in carpooling. Priority lanes for carpools (and buses) have initiated measurable increases in the number of carpools using Oakland Bay Bridge and Golden Gate Bridge in San Francisco and Shirley Highway in Arlington, Virginia.

While these examples show that carpooling can increase in the presence of incentives, it is not clear how much additional carpooling would occur if major incentives were provided. There may be diminishing rates of return as larger numbers of people begin to form carpools, and effectiveness may vary from area to area. In spite of these open questions, incentives offer the potential for producing higher rates of carpooling, and should be given serious consideration in planning carpool systems. This section will discuss a number of possible incentives.

INCENTIVES FROM THE EMPLOYER

Introduction

Most commuters in many metropolitan areas park at facilities provided by their employer. In addition, this report has emphasized the role of employers in promoting carpooling among employees. Consequently, employers have a major potential as a source of incentives for carpooling. On the other hand, it may be difficult for an outside agency to persuade an employer to establish incentives, and more particularly it may be difficult to achieve any uniformity of incentives among employers in one metropolitan area. With these limitations in mind, several employer incentives will be reviewed.

Potential Incentives From Employers

Preferential Parking - Parking specifically reserved for carpools and conveniently located can encourage carpools if parking is in short supply or if the carpool parking would substantially reduce the time or distance between parking lot and building. A possible disadvantage with this technique is opposition from those who may now have preferential treatment on the basis of rank or seniority and compromises may be necessary.

Carpool Loading Areas - Special loading/unloading areas provided for carpools can be an added convenience, especially where large numbers of personnel work in one building or where parking lots are large. Such loading areas could provide nearly as much convenience as preferential parking locations and may not involve so many objectiions from people with existing parking privileges.

Financial Bonus - At least a few firms are experimenting with cash payments to employees who don't drive their cars to work. One firm pays non-drivers one dollar a day. (This type of incentive should be coordinated with incentives for mass transit, so that people don't switch from transit to carpools and thus increase vehicle travel.)

Work Schedules - Carpools may be difficult to form if people find they are delayed in leaving work by the need to wait for someone who leaves later or must walk substantially further to reach the parking lot. Such delays may be especially discouraging if they cause the person waiting to experience greater traffic congestion in the parking lot or on the street system. So one incentive could be to allow carpoolers to leave a few minutes early (or arrive a few minutes late) in order to optimize their schedule. Another aspect of this is to publicize the importance of letting employees leave on schedule; meetings or other tasks which run "just a few minutes longer" can rapidly defeat carpools.

Vanpools/Buspools - This report refers to "carpools" but just as easily in nearly every case one could substitute the term "carpools/buspools/vanpools," because all such high-occupancy vehicles could be involved. Vanpools and buspools are generally more highly organized than carpools and generally imply more direct financial support from employers, including provision of vehicles for employee use. Providing vanpools or buspools would obviously be a strong incentive to employees because they need not use their own car to commute. Detailed evaluation of buspools and vanpools is beyond the scope of this report, however, the reader is referred to the existing literature (see Bibliography).

Marketing Process - An effective marketing process will itself be an incentive, because it will be convenient, personal, helpful, and otherwise conducive to participation in carpooling. (See Section VI.) In this connection, an effective marketing campaign should reward the employee with recognition, besides more tangible benefits.

Related Services - An employee will not leave his car at home and ride in a carpool if he believes he may need his car at work. To offset this objection to carpools, employers can provide several incentives:

Company cars - Employers can provide vehicles for between-plant travel, unexpected daytime business travel, or for contact with clients. (This may be less expensive than compensating employees for use of their own cars.) Note that this incentive was rated very high in the attitude survey in Los Angeles.[33]

Food service - Larger employers who provide lunch rooms may be able to improve the rate of carpooling by improving food service so that employees are less likely to want to travel elsewhere for lunch.

Mass transit connections - If an employee leaves his car at home but unexpectedly needs a car during the day (for either business or personal errands), he may be able to use mass transit instead. If mass transit service is available but not within walking distance, a shuttle service could be established between the employer's facility and the nearest public transportation.

Summary - Several incentives have been summarized here. Some are more attractive than others, but all should be considered as potential ways to encourage carpooling at employers. Organizations involved in managing carpool systems (government agencies, in particular) should themselves provide as many of these incentives as possible to their own employees to demonstrate them and to help promote them. The next sub-section will discuss incentives available to the general public.

INCENTIVES FOR THE GENERAL PUBLIC

General

Incentives (and disincentives) provided to the general public either by government agencies or the private sector can equitably influence all automobile commuters regardless of where they are employed. Furthermore, a broader range of incentives can be provided than employers could provide and there would be no need to rely upon the generosity or commitment of individual employers.

Preferential Treatment On Highways

General - The use of exclusive lanes, reduced tolls, and other preferential treatment of high occupancy vehicles on highways have received a great deal of attention in recent years. Some experience has been accumulated which shows that the number of carpools using a facility will be increased by such techniques. These techniques are generally site-specific, however; that is, an exclusive bus/carpool lane on a freeway will only encourage carpools in the travel corridor served by that freeway. Furthermore, carpools may be attracted to this corridor from other facilities, resulting in an increase in vehicular travel rather than a decrease. Thus, the use of this type of incentive requires detailed transportation planning evaluation on a case-by-case basis, particularly where increased congestion will be incurred by non-carpoolers. Nonetheless, these now appear to be viable and useful for encouraging carpooling.

Exclusive Lanes or Roadways - Exclusive lanes or roadways involve giving priority treatment to high-occupancy vehicles, thereby reducing travel time. Dramatic travel time savings have been demonstrated in San Francisco and Washington with such facilities. The benefits of this technique are greater where new facilities, or at least new lanes, are involved. Where the exclusive lane must be an existing lane removed from general traffic service, there are disadvantages which require detailed study. Removing one lane from use on an expressway may increase congestion in the remaining lanes to the extent that there is no net gain in travel efficiency or air quality. Safety and cost are other concerns. Several reports dealing with this topic are listed in the bibliography. This type of incentive has more potential for long-run, permanent effect than it does for short-term change in travel.

Preferential Bypass of Queues - Congestion points may provide a relatively simple opportunity for preferential treatment of carpools. Time-consuming queues may form at toll booths, certain freeway entrance or exit ramps, wherever traffic flow metering is installed, at certain intersections, or other high-traffic locations. In such situations provision of a bypass for carpools would provide the incentive of reduced travel time. This technique has been used in the approaches to toll facilities on the Oakland Bay Bridge and Golden Gate Bridge in

San Francisco, and at a metered freeway entrance ramp on the San Diego, California, Freeway. Physical arrangements may not permit the use of this technique in many locations without some new construction (of an extra ramp, for example). Also, unless such locations are widespread or carry particularly large amounts of traffic, the net effect on total vehicle occupancy may be small.

Reduced Tolls - Providing lower tolls for carpools would be a direct economic advantage for carpools, and could be combined with exclusive lanes at toll booths for greater effect. This type of incentive is in use in Philadelphia and San Francisco. Such an incentive could be low in initial cost but might require additional toll collectors or additional enforcement officers. Loss of revenue may be a consideration as well. On the other hand, this could be an effective technique if several toll facilities in a metropolitan area carry a substantial fraction of present traffic and all utilize this incentive.

Preferential Treatment In Parking

Municipalities that operate parking facilities with substantial amounts of employee parking could institute reduced parking rates, preferential locations, reserved space, or guaranteed space for carpools. If other parking rates are increased to compensate for the lower rate for carpools, the net effect should be no loss in revenue and no loss in transit ridership. Private facilities could perhaps be required to institute similar policies through municipal licensing regulations. Transportation Control Plan regulations often contain parking regulations and should also be considered as possible mechanisms for implementing such incentives throughout a metropolitan area. (The legal aspect of this incentive was not investigated for this report.) This incentive could effectively be coordinated with either encouraging or requiring employers to provide preferential parking for carpools, so that together nearly all employees in the region would be treated equitably. From experience to date, and analyses performed for transportation control plans, parking supply regulations are among the most effective incentives for carpooling and should be encouraged.

Other Public Incentives

Reduced Taxes - It is conceivable to reduce license, fuel, or vehicle taxes for carpoolers. Such an incentive could be regressive, however, and would probably be costly and difficult to regulate. This incentive did appear to be attractive to the potential carpoolers in the Los Angeles attitudinal survey, however.

Reduced Insurance Rates - Several insurance commissions have recently taken action to allow reduced automobile insurance rates for drivers who regularly use carpools. This should be encouraged, but the effectiveness of such a technique is unclear at this time.

Relationship to Transportation Control Plans

Operating carpool systems could perhaps be offered as an incentive to employers by arranging for preferential treatment of such employees in Transportation Control Plans (TCP's). For example, some TCP's involve reductions in employee parking. Employers could be exempted from some or all of this requirement in return for operation of a carpool system plus provision for incentives such as transfer of existing parking spaces to carpool use. Alternatively, transit fare discounts could be given to firms who encourage carpooling and operate employer mass transit incentives.

Virtually any other significant impediment to travel, such as parking supply reductions, increased parking fees, and other disincentives, will tend to increase carpooling if the disincentive causes an increase in cost or loss of convenience which carpooling will ameliorate. From the standpoint of TCP's, however, these effects are not additive;

rather, carpooling is a major mechanism for accommodating the travel prevented by the disincentive.

SUMMARY

This section has reviewed a number of incentives that can be explicitly provided in order to encourage the use of carpools (and other high-occupancy vehicles in most cases). Such incentives should be well publicized if they are used, along with publicity of the direct personal benefits of carpooling discussed in Section II.

Incentives can reduce travel cost, reduce travel time, increase convenience, or otherwise provide additional reasons for a person to choose carpools over driving alone. Incentives can help to induce a person to change his longstanding habit of travelling alone.

Experience shows that incentives can lead to increases in carpooling, but the duration and extent of such effects are not yet clear. Studies of commuter attitudes imply that at least a minority of present drivers can be motivated to join carpools, and that certain incentives would help to induce carpooling among this minority. Gasoline shortages in early 1974 showed the potential value of public disincentives for encouraging carpooling.

Employers can provide significant incentives to carpooling, but it may be difficult to motivate employers to provide such incentives or to achieve uniformity of incentives among employers in a metropolitan area. Several types of incentives from employers are in use and are of potential value.

Incentives provided for the general public by government agencies in the private sector could be more equitably distributed than employer-provided incentives, and a wider range is possible. Preferential treatment of carpools on highways is of proven local value but is site-specific, is perhaps not significant to a metropolitan area, and requires detailed evaluation on a case basis. Preferential treatment in parking price, supply, or location could be most widely distributed and would be readily and effectively coordinated with employer parking incentives and thus is recommended as the best major public incentive for carpooling. Other public incentives are available and worthy of experimentation but are of unproven value.

Incentives have the potential for assisting the operation of a carpool system, especially in initial operation. To be effective, their operation must be well planned and their existence well publicized as part of the carpool system marketing effort. Incentives should be provided to both the general public and to specific employee groups. Transportation Control Plans should provide incentives for employers to operate carpool systems.

Table 3, reproduced from Reference 40, summarizes the major types of incentives and several characteristics of each. Each of these types of incentives was discussed in this Section.

Table 3. SUMMARY OF INCENTIVES

	Potential Sponsor					Cost to Sponsor		Implementation	
	Government Agency	Employer	Citizen Group	University/ College	Other Organization	Initial Cost	Continuous Cost	Operational	Planned
Cost-Related Incentives									
Parking Cost	*	*		*	*	Low	Low (or net revenue	*	
Automobile Ownership Cost	*	*		*		High	Varies, can break even	*	
Automobile Operating Cost	*	*		*		High	Low (or net revenue	*	
Travel Time Incentives									
Vehicle Priority Traffic Control	*					Moderate/ High	Moderate/ High	*	
Convenience Incentives									
Preferential Parking Space Allocation	*	*		*		Low	Low	*	
Facilities for Carpoolers	*	*	*	*	*	Low/ Moderate	Low	*	
Adjustments to Working Hours	*	*		*		Low/ Moderate	Moderate High		*
Vehicle Restriction	*					Low	Moderate		*
Parking Restriction	*	*		*		Low	Low		*
Legislation	*					Low	Low		*
Intangible, Non-Travel Related and Other	*	*	*	*	*	Variable	Variable	-	-
Organizational Incentives	*	*	*	*	*	Variable	Variable	-	-

SECTION VIII

REVIEW OF OTHER ISSUES

GENERAL

This Section treats several miscellaneous issues related to carpooling and carpooling systems.

LEGAL ASPECTS

Several legal questions can arise in connection with carpools or carpool systems. These questions can be categorized as issues relating to (1) legal authority, (2) regulations, (3) liability, (4) compensation, and (5) insurance. Each of these will be briefly reviewed.

Legal Authority

The question of legal authority to impose incentives or disincentives must be investigated in each locality contemplating such action. The U.S. Secretary of Transportation apparently has no authority under present laws to establish preferential lanes for carpools or to initiate other incentives. Some local authorities or states have such authority but others do not. Special legislation may thus be required. Preferential parking may also require new legislation in some states or municipalities.

A related question is the power to set tolls. Such authority varies among jurisdictions but, except in special circumstances, tolls cannot be established on the Federal Interstate highway system so the use of new tolls as a disincentive is impossible on many major urban highways.

Regulations

Carpooling itself appears to be the subject of little or no explicit government regulation. Carrying passengers for a profit is, however, subject to either local or Interstate Commerce Commission regulations, or both. Carpools organized strictly for mutual convenience and cost sharing, which this report has concentrated upon, should encounter no difficulty with common carrier regulations.[41] Vanpools or other operations involving either profit to the operator or institutional sponsorship may be subject to common carrier regulation, and may require special driver's licenses for the drivers (as in Minnesota).[37]

Liability

Carpool system operators should investigate their state motor vehicle laws to determine the liability of a carpool driver to his passengers. In a study for FHWA, it was concluded that these guest provisions in motor vehicle laws vary among the states, but that it is generally considered that a reciprocal driving arrangement (as in carpools) makes the guest statutes inapplicable.

The FHWA's study also investigated the question of the liability of the sponsor of a carpool system. Generally, the type of carpool system described here, in which the operator provides no coercion but only provides matching information, would involve little or no additional liability beyond that resulting from workmen's compensation laws. Greater involvement, such as providing company vehicles for use by carpoolers, involves added legal responsibility which should be investigated by an employer's legal advisors.[41]

In this connection, it would be prudent to clearly state the sponsor's responsibility and liability in the literature sent to system applicants. Many carpool questionnaires reviewed for this report incorporate a "disclaimer of liability" and ask that an applicant sign this statement and thus acknowledge the sponsor's lack of liability. While such disclaimers may be useful as information tools, the FHWA considers the disclaimers themselves do not alter the sponsor's liability and thus it may be unnecessary to ask carpoolers to sign such statements.

Compensation and Taxation

FHWA and HUFSAM have examined the conditions under which a carpool would involve compensation subject to Federal income tax. According to FHWA, the Internal Revenue Service position is that carpools do not alter the taxable income of a carpool participant so long as any compensation (to the driver, e.g.) does not exceed costs. Incentives provided by employers may, however, be treated as fringe benefits and thus be taxable.[37,41] More detailed review should thus be undertaken where potentially taxable benefits to carpoolers are contemplated.

Insurance

Carpool system operators have found that one of the most frequently asked questions concerning carpools is the effect on a carpooler's insurance. Almost universally the answer which is provided is that the potential carpooler should contact his insurance company to be sure of his coverage and the effects on his rates. This is the recommended position. Generally, the insurance industry has taken a positive attitude towards carpooling; as this is being written action is underway to revise insurance plans and insurance laws to encourage carpooling and clarify the insurance issue. In the interim, carpool system operators should urge carpoolers to inform their insurers and check their coverage, and operators should publicize any local statutes which affect this issue.

Summary

This Section has described the major legal issues which may arise in connection with carpool systems. Most carpool systems would not be expected to generate serious legal difficulties. Applicable laws and regulations vary considerably among locations, however, so carpool system organizers should obtain local legal advice regarding their system.

RELATIONSHIP BETWEEN CARPOOLING AND OTHER TRANSPORTATION ELEMENTS

Planners of carpool systems should anticipate the need to coordinate their systems with other elements of transportation, notably mass transit systems and taxi operators. Section V recommended that mass transit system operators be included in planning and operating carpool systems and cited Knoxville as an example of where this is being effectively done. There are two elements to this coordination: technical and political.

From a technical viewpoint, carpools can be seen as an adjunct to, or a part of, a coordinated transportation system. Data being collected from carpool surveys can be used for revising or expanding bus service, planning park-and-ride facilities, and other transportation planning functions. Carpool destination lists should include key transit terminals. In fact, carpool systems can be used to increase transit ridership. Many people probably drive all the way to work because the transit system doesn't reach their home. Some of these people might be diverted to transit if they could join a carpool destined for a transit terminal (with preferential parking for transit, perhaps). Buspools or express bus routes might readily be formed in areas where the density of demand shown by carpool surveys would warrant such service. Carpool information kits mailed with the matching lists could well follow the example of the WBZ-ALA system in Boston and include maps of the transit system, bus schedules, and other information to encourage use of available public transportation.

On the political side, carpool system planners should coordinate with transit and taxi operators so that these elements will not feel the carpool system is a competitor and contrary to their interests. Transit and taxi operators should be shown the advantages to them of increased carpooling, such as increased off-peak travel on transit and in taxis by the carpool riders who need to make off-peak trips but don't drive their own cars. Also, transit operators should be offered the use of the carpool survey data, and be asked for advice on planning what is, after all, a transportation system.

The problem of coordinating transit and taxi service with carpools has been explored in greater detail in one of the reports prepared for FHWA. Rather than duplicate that material here, the reader is referred to that report, Reference 42.

MONITORING RESULTS

Throughout this study, it has been difficult to quantitatively assess the impact of carpool systems on the amount of carpooling, vehicle occupancy, fuel consumption, air pollution, total travel, or traffic congestion. Yet it is essential in the long run to determine these impacts in order to understand [illegible] effective carpooling is at achieving the objectives of clean air and efficient transportation, particularly when compared with other techniques in Transportation Control Plans.

To this end it is suggested that carpool systems include provisions for measuring the degree of change in travel and in carpool use. The details of doing this are the subject of another research project now underway for the U. S. Environmental Protection Agency and thus it would be impossible to rigidly define here how to undertake this monitoring. The following tentative guidelines are, however, offered:

1. Carpool questionnaires should ask the applicant to identify his current mode of travel to work. To keep the questionnaire simple, this should be just one, simple multiple-choice question. The survey form should allow the person to identify how many people are in his carpool if he rides in one.

2. The matching programs should include a master list output which can be used to form mailing lists for subsequent surveys. Security and privacy guarantees should be observed, however. (Employers could be asked to distribute such "after" surveys rather than mail them to employees of participating employers.)

3. Periodically a mail survey should be performed of (1) applicants to the matching service and (2) randomly chosen members of the general public to ascertain their mode of travel. Analysis of such surveys will show the changes in vehicle occupancy over time.

4. Transportation Control Plans should require the type of surveys described here — both before and after system operation — as part of any mandated carpool system.

More elaborate monitoring plans may be conceived. Relatively straightforward monitoring is suggested so that its cost will not be excessive and so that the monitoring effort will not become a burden upon the carpool system applicants. Experience with carpool systems will show how such monitoring efforts should evolve.

SECTION IX

ESTIMATING THE POTENTIAL FOR CARPOOL SYSTEMS

GENERAL

Most of this report has consisted of a practical review of present and proposed carpool systems. Such systems have evolved on a rather ad hoc basis, there being little detailed scientific basis for planning carpool systems. In the process of this study some concepts of a more theoretical nature have been encountered which are relevant to the question of increasing automobile occupancy; this Section will review these concepts and also examine the role of carpools in urban transportation planning.

CARPOOLS AND TRANSPORTATION PLANNING

One way a transportation planner would view carpool systems is as a mechanism which alters some of the mathematical relationships he uses to describe existing traffic and plan future transportation networks. Three of these relationships which could be altered are automobile occupancy, mode split, and traffic assignment. Each will be discussed in brief.

Automobile Occupancy

Automobile occupancy is the element which relates the number of person trips to the number of automobile trips. In the urban transportation planning process, planners often use a mathematical model which describes how automobile occupancy varies with trip purpose or by land use. Auto occupancy data used for these models are normally collected in traffic surveys. Past practice has been that the measured auto occupancy data are also used for forecasts of future travel. The trend has been for average auto occupancy to decrease with time.[36] Carpool systems are intended to increase the number of people who ride together and thus to increase average auto occupancy. If such systems succeed in reversing the trend towards lower auto occupancy, there are major implications for planning of future transportation systems or elements. The effect of carpools is particularly important for transportation facility planning because average auto occupancy is generally lowest during the peak traffic flows of the day; the size and location of most urban transportation facilities are determined by these peak traffic demands.

Transportation planners do not generally consider the number of carpools directly; rather, the usual practice is to deal with average auto occupancy. Furthermore there is no standard definition of whether a "carpool" is 2, 3, or more persons. Consequently it is necessary to examine the relationship between the number of carpools in traffic and the average auto occupancy.

In the study of the Hollywood Freeway referred to earlier, a count was made of automobile occupancy during the morning peak period. The results of that count were as follows:[33]

Number of Persons in Vehicle	Percentage of Vehicles	Percentage of Persons
1	88.6%	79.0%
2	10.1	18.0
3	0.9	1.6
4	0.4	1.4
Total	100.0%	100.0%

Average occupancy = 1.131 persons/car

The above data show that more than 11 percent of the vehicles carry two or more occupants. But it would be erroneous to conclude that all vehicles with two or more (or three or more) persons were carpools. A carpool is generally considered to be an arrangement in which people regularly ride together for a specific purpose such as the journey to work. Some of the persons recorded in the above sample are probably only occasional passengers; their purpose may merely be to accompany another person in order to obtain the vehicle for use during the day, for example. In fact, a mail survey of drivers using the Hollywood Freeway showed that fewer than 7 percent of the respondents consider themselves as belonging to a carpool. The report comments upon this apparent discrepancy as follows:

> "Among the 1896 respondents in this study, 6 percent or 108 belong to a carpool; 93 percent (1763) do not, and 1 percent, or 25, did not indicate whether or not they carpool. Auto occupancy samples during morning commuting hours on the freeway indicate that 10 to 12 percent of the vehicles carry more than one occupant, and knowledge of this fact has led to the speculation that the survey might be biased in that a disproportionately low number of carpoolers returned the questionnaire. We do not believe that the bias speculated upon actually exists. Rather, it is believed that many of those commuters who join with others to ride together only occasionally, or under special circumstances, probably do not consider themselves as 'members of carpools' and would, therefore, answer negatively to the carpool membership question ....
>
> "Pursuing this rationale, a substantial number of two-or-more-occupant vehicles would likely appear on the freeway on any given day, occupied by commuters who do not think of themselves as regular carpoolers."33

Another way of stating this is that measured auto occupancy provides an overestimate of the amount of organized carpooling.[6] The implication of this observation is that the amount of increased carpooling must be more than one would initially expect in order to achieve increases in average auto occupancy. In the present example, the average auto occupancy was 1.13. If all vehicles with two or more occupants were considered to be carpools, then doubling the number of carpools would double the number of persons in cars with more than one occupant. In the present example, average auto occupancy would become 1.30, a substantial increase. For the same volume of persons, the vehicle volume would be reduced by 13 percent. In contrast, if the number of carpools is considered to have been indicated by the mail survey, then doubling the number of carpools would increase the number of sampled drivers in carpools from 6 percent of the respondents to the mail survey to 12 percent. Average reported carpool size was 2.3 persons. Doubling the reported rate of carpools would increase average vehicle occupancy to only 1.20, and would reduce the number of vehicles by only 6.1 percent or less than half as much as with the prior assumption.

This exercise illustrates the idea that the amount of carpooling must be increased by more than would be expected from examination of only vehicle occupancy data. It also demonstrates the sensitivity of traffic volume estimates to assumed vehicle occupancy or amounts of carpooling.

Some analytical work has been done by the U.S. Department of Transportation to examine the potential for altering vehicle occupancy through greater amounts of carpooling. In this work, national survey data were used to establish the distribution of occupants among vehicles, and then to examine the average vehicle occupancy separately for vehicles with multiple occupants. It was found that cars with more than one person carry an average total of 2.5 persons, and that such multiple-occupancy vehicles carry roughly 30 percent of all auto commuters. (This study separately reached the same conclusion reported earlier in this section that the national level of carpooling is much less than would be indicated by average auto occupancy.) Calculations were made to determine the effects on average occupancy of various postulated changes in the amount of commuters in multiple-occupancy vehicles. One calculation was to determine how much change in the use of multiple occupancy vehicles would be needed to increase average auto occupancy by 50 percent. The report states:

> "There is frequent discussion of raising average total occupancy from its present 1.2 to (for example) 1.8. To achieve such a considerable shift would require an increase in the proportion of total individuals traveling in multiple occupancy autos from 27.6% to about 73%. The corresponding rise in the proportion of multiple occupancy autos is from 13.3% to approximately 53%. The associated changes required in terms of other variables certainly suggest that the proposed increase in average total occupancy would be quite difficult......
>
> "......consider the hypothetical average occupancy increase to 1.8, which was discussed earlier. Maintaining the average multiple occupancy at the current 2.5, this results in a 35% reduction to work trip auto usage, which is significant. However, as mentioned in the previous section, the occupancy increase (to 1.8) required to achieve such a reduction is substantial and possibly unattainable."[6]

As another case, the DOT report calculates the effect of an average auto occupancy of 2.5:

> "As discussed earlier, the average multiple occupancy is currently 2.5. As a limit, an ideal case in which all cars carry an average of 2.5 commuters is examined. This means that the average total auto occupancy level is 2.5 and that the proportion of total travelers in multiple occupancy autos is 100%, both of which are quite improbable. Under these highly idealized circumstances, the curves indicate a maximum reduction in auto usage (for commuting) by approximately 48%."[6]

The DOT report demonstrates some of the difficulties associated with marked increases in auto occupancy. This study also demonstrates that the greatest number of commuters in multiple-occupancy vehicles are in vehicles with one other person; it is apparently much more difficult to form groups of three or four. The relatively large number of people riding alone in cars and the small number with two, three, or more suggests that "the greatest marginal benefit to society in terms of reduced traffic congestion and lower numbers of mobile pollution sources comes with the commuter's decision to join with one other individual to share the ride to work."[44] This argues against defining carpools as three people or four people for the purpose of creating incentives.

Mode Split

Another part of the transportation planning process is the estimate of the manner in which person trips are divided ("split") among the various travel modes (auto, rail, bus, etc.). Increased carpooling may significantly alter modal split. It is conceivable, for example, that people will switch to carpools from transit, not only from other cars.[43] Or carpool service to transit terminals could result in ridership increase on some transit lines. Furthermore, the use of carpools may alter the distribution of mode split. That is, carpooling may disproportionately attract people from outer suburbs versus inner suburbs, from certain income groups, or from certain travel corridors. (This possibility will be further discussed in the next sub-section.) Another element in mode split is that people who have a choice between modes often make that choice based upon some weighing of cost and travel time. If carpooling reduces highway congestion, the highway routes may become more attractive to some people who now use transit. This could result in lower transit ridership or otherwise alter mode split relationships. The relationships between carpooling and mode split are not well understood and require further study.

Traffic Assignment (Route Selection)

Once a person has chosen which mode to use, he must next choose his route. (Actually the route choice and mode choice processes are probably iterative to some degree.) The planning process which analyzes this route choice is referred to as traffic assignment; on paper the analyst "assigns" the forecasted traffic to a route in order to analyze the behavior of the facility with the forecasted traffic. As noted earlier, travelers consider travel time, travel cost, and other factors in choosing among routes.

Increased carpooling could alter route choice and forecasting of traffic assignments because carpooling could reduce congestion and alter relative travel times for alternative routes; incentives such as altered toll schedules could revise the cost relationships; and disincentives such as ramp metering or parking restrictions could alter time, cost, or convenience elements.

Furthermore, there is some evidence that carpooling alters travel patterns in a more basic way. In an analysis of present carpool habits in California, the Hollywood Freeway study report showed that people who carpool differ in their travel patterns from those who do not. Table 4 summarizes some of the differences found to be statistically significant. Carpoolers travel further; have a greater tendency to work for government agencies, large employers, and in high-density areas; and are more apt to arrive at work during the peak period and have to pay for parking. This implies that increased carpooling will not draw evenly from the non-carpooling population but will draw more people from some locations, travel patterns, and travel periods than others. In short, carpooling could alter present travel patterns.

Table 4. DIFFERENCES IN TRAVEL BEHAVIOR BETWEEN CARPOOLERS AND NON-POOLERS ON HOLLYWOOD FREEWAY, 1972

	Data (Sample of 1896)	
Characteristic	Carpoolers	Non-Poolers
Average distance to work	19 miles	16 miles
Average travel time to work	40 minutes	36 minutes
Employed in high-density areas	66%	49%
Employed in low-density areas	34%	51%
Employer has 25 employees or less	16%	28%
Employer has 100 employees or more	66%	48%
Employer is government agency	27%	16%
Use free parking	42%	62%
Arrive at work in peak period (7-8)	58%	36%

Source: Reference 33.

In another study, a review was made of the characteristics of applicants to the WBZ-ALA carpool system in Boston. This study showed that the applicants for the WBZ-ALA matching service are apparently not representative of Boston area commuters in general, but rather live further from their jobs and tend to live further from Boston than do average commuters.[44] Another analysis of the WBZ-ALA system showed that applicants are much more likely to work in the Boston central business district than are Boston area employees on the average.[14] Both of these results imply that increases in carpooling will alter travel patterns. Because these analyses apply to very specific conditions, however, it would be difficult to generalize upon the exact type of travel pattern changes that would occur. Clearly the effect would depend upon which employers participated, what incentives were provided, and other elements of system design and operation.

CARPOOLS AND AMOUNT OF TRAVEL

General

Carpooling is of interest to EPA chiefly because of its potential for reducing the amount of vehicle travel, and consequently the amount of air pollution emitted by motor vehicles, in metropolitan areas. Transportation Control Plans (TCP's) which include carpool matching systems usually have claimed no explicit reduction in vehicle-miles of travel (VMT) as a result of carpool matching systems; rather, the carpool systems have been analyzed as a mechanism for accommodating the travel eliminated by parking supply reductions or other strategies. Experience to date shows this to be a rational approach; there simply has been no demonstration of marked reductions in VMT as a result of carpool systems. On the other hand, carpooling, technically at least, offers the apparent potential for drastic reductions in travel over and above the effect of transit systems or parking restraints. In concept, widespread use of carpooling (meaning, widespread increases in vehicle occupancy to three, four, or five persons per automobile) could reduce travel to one-half, one-third, or less of its present amount. But it should be recognized that substantial amounts of carpooling are probably practical only for travel to and from work. The work journey is the only travel occurring in sufficient quantities in place or time to allow efficient, regular riding together. Travel to work accounts for only about one-third of total travel by automobiles in typical U.S. urban areas.[6] Thus, there is a very real limitation on the amount of VMT reduction which carpooling can achieve.

Number of Carpools and Data Base

Some work has been done to examine the amount of VMT reduction potential of carpool systems. The DOT paper discussed above included the example of increasing carpooling to the point that all commuters would ride in vehicles with an average auto occupancy of 2.5, thereby reducing the average commuting travel by 48 percent. As commuting travel is only one-third of total metropolitan area VMT, the maximum effect of such a change in occupancy would be a reduction of approximately 16 percent.

To achieve such increased amounts of carpooling with a carpool matching system would require a substantial data base. As an example, consider a hypothetical case in which the goal is to reduce total VMT by 10 percent. This implies reducing commuter VMT by 30 percent. If multiple-occupant vehicles maintain an average of 2.5 persons per auto, and thus new carpools are formed only among present drivers of single-occupant vehicles, then it can be shown that 50 percent of present drivers must form carpools leaving 25 percent of present drivers still driving alone. If the chief source of carpool formation is a matching system, then the matching system must include at least 50 percent of all present drivers to reduce VMT by 10 percent through carpooling. This 50 percent figure in the Boston area would amount to more than three hundred thousand drivers, or several times the number of applicants to any present carpool system.

Matching Rate

A related issue is the rate of matching applicants. To form a given number of carpools will require many extra applicants to the matching system because no system can achieve 100 percent matching. Factors which influence the rate of matching include the size and number of zones or cells into which the metropolitan area is divided, the number of work schedules, and the number of applicants.

Number of Applicants - Given a system of matching and a distribution of origins, destinations, and schedules, it is apparent that the probability of finding a match will increase as the size of the data base increases. The exact nature of this relationship is not clear, however. One writer has suggested that the probability function for making a match is S-shaped, so that the matching rate is initially low but then begins to increase rapidly as the number of applicants increases beyond a certain critical value.[45] If true, this would explain the relatively low initial matching rates found with some systems (such as WBZ's 25 percent). In another paper, a computer simulation process was used to predict the change in matching rate as the number of applicants increased. The simulation indicated that there is no critical point for the matching rate, but that matching rate will increase at a diminishing rate as the number of applicants increases. The simulation was for the WBZ-ALA system, and predicted that 43,400 applicants would be required for 50-percent matching.[44] Other programs have shown high matching rates with fewer data.

Variety of Origins, Destinations, and Schedules - With a given number of applicants to a carpool matching service, the matching rate will decrease as the number of combinations of origins, destinations, schedules, and preferences is increased. For example, the simulation study referred to above predicts that approximately twice as many applicants would be needed to achieve a 50 percent matching rate with seven work schedules as with five work schedules.[44] One of the DOT papers referred to earlier developed a probability method for calculating the size of origin or destination cells based upon the desired matching rate.[45] Fewer combinations produces a higher matching rate, but of course some of the resulting matches may be of little utility. Larger origin zones or destination zones would increase matching rates but the zones would be so large that two people in one zone may be too far apart for practical carpooling.

One implication of this has already been observed: matching rates are inherently higher in destination-based systems, where the number of combinations is much smaller than with regional systems. For a given data base, and probably for a given amount of effort, higher matching rates can be expected with destination-based matching systems than with regional systems. Fairly high matching rates have been attained with data bases of only a few thousand with some destination-based systems.

Number of Carpools From Matches

An unknown question in most cases reviewed for this study is how many carpools are formed from the proposed matches provided to applicants for carpool matching service. There is no known correlation between carpool matches and carpool formation. The first attempt to discover this correlation appears to be a survey planned for this spring in Boston. The U.S. Department of Transportation intends to mail a detailed follow-up questionnaire to each person matched by the WBZ-ALA Commuter Computer campaign.[14] This study will include questions on travel mode (including carpools) both before and after the person applied for matching. The DOT survey promises to be very important as it will be the first measurement of how effective a regional carpool system is at actually aiding people to form carpools.

CARPOOLS AND AIR QUALITY

Strategies to reduce emissions of air pollutants from passenger cars can do so in two ways. Reducing the amount of vehicle travel (VMT) directly eliminates emissions. Improving traffic flow reduces the rate of emissions per vehicle-mile of travel. Carpooling can produce both types of effects.

VMT Reduction Effects

The formation of carpools directly eliminates vehicle trips and thus can be expected to concomitantly eliminate the air pollutant emissions associated with those trips. If enough carpools are formed that, say, 3 percent fewer people drive to work, this would initially appear to eliminate (roughly) 1 percent of total trips and thus 1 percent of all automobile emissions in an urban area.

There are two elements which may alter this expected amount of emissions reduction, however.

First, there is the potential for changing the mode split. Some of the incentives for carpooling, such as parking supply restrictions, may induce more transit travel and this could reduce emissions by more than expected. On the other hand, some people may shift from transit to carpools, thereby resulting in less emissions reduction. The latter possibility seems more likely than the former, in view of the well-established propensity for Americans to prefer automobile travel to mass transit.

Second, carpooling could result in an increase of non-work travel owing to the greater number of vehicles available at home for people to use. The amount of this counter-productive travel will depend upon many elements and cannot be predicted. It would be hoped that, in the long run, carpooling would result in a lower specific rate of automobile ownership so that the amount of extra non-work travel would gradually be reduced.

Prediction of the air quality impact of carpooling should thus include an awareness of these two effects.

Congestion Effects

Substantial carpooling would reduce the number of vehicles using particular highway facilities in any unit of time and could therefore reduce congestion, increase speed, and reduce emissions per vehicle-mile. It is likely that these effects, if they occur, will not be distributed evenly in a metropolitan area. Rather, one would expect the effect to be concentrated near major employment centers where the concentration of employment would both encourage and facilitate carpooling. This points to an advantage of carpooling programs being used where congestion is worst; under such conditions, carpooling could reduce emissions by more than VMT. That is, a 1-percent reduction in VMT would result in more than 1 percent reduction in emissions, because of the combined effect of less congestion and less travel.

This benefit to traffic flow may be offset, however, by traffic induced or diverted from other routes by the reduced congestion. (In this respect, carpooling is no different from other measures to improve traffic flow.)

ENERGY ASPECTS

Carpooling, to the extent that it reduces vehicle travel, will aid in current efforts to consume less fuel for transportation, without any loss in mobility. It has been estimated that "Increasing the auto occupancy 30 percent at rush hours can save 5 percent of the total highway fuel consumed and 3 percent of the nation's total transportation fuel needs ...." In comparison, "Approximately 3.5 percent of highway fuel would be saved by a shift of 10 percent of the auto mileage to buses. This would require a 100 percent increase in bus patronage ......" In fact, "Already more passengers are carried in carpools that (in) all other forms of mass transportation combined."[46]

In another sense, carpools can be seen as a means for coping with future increases in person travel volumes without any increases in vehicle travel or fuel consumption, if the empty seats in passenger cars are seen as unused transportation system capacity. As population and employment grow, carpooling could conceivably absorb all or nearly all of the increased work-related movements of people with no additional fuel consumption (or construction of transportation facilities). Automobiles can thus be considered as an under-utilized transportation resource which carpooling would more efficiently use.

SECTION X

SUMMARY AND RECOMMENDATIONS

SUMMARY

This report presents the findings of a study of systems designed to encourage the use of carpools for the journey to work. The initial intent of this report was to evaluate several existing systems which are attempting to encourage carpooling in certain metropolitan regions in the U.S. by providing a computer service for matching prospective carpool partners. During the study it became apparent that experience with other kinds of carpool systems, notably those intended for one destination or one employer, would also be worthwhile to review because experience with such systems could be helpful in planning and evaluating systems for region-wide use. Several region-wide and several single-destination carpoll systems were then critically studied.

In general it was found that carpooling is in an extremely dynamic state. Systems are being planned or put into initial operation throughout the U.S., and existing systems are rapidly evolving as experience accumulates. Few data were found to be available by which effectiveness of these systems could be judged. Consequently, most of the conclusions of this report must be considered tentative. In some cases, even tentative conclusions were not yet possible because of the lack of sufficient experience.

Section I of this report provided background information on carpool systems. The present interest of the U.S. Environmental Protection Agency

(EPA) stems largely from plans to use carpooling as one of the strategies for reducing air pollution in many U.S. metropolitan areas. In addition, recent shortages of gasoline in some parts of the U.S. have led to increased interest in carpooling as a means to conserve fuel. Congress has recently asked EPA to work with the U.S. Department of Transportation to determine what measures might lead to significant increases in carpooling.

Substantial activity is underway throughout the U.S. to organize and operate systems to encourage the use of carpools. A number of these have come about as a result of requirements in Transportation Control Plans to provide a carpool matching service. Most of these plans do not include detailed requirements for carpool systems; thus, this report is addressed to the need for development of detailed guidelines for organizing carpool systems.

Section II summarized the benefits of the widespread use of carpools. Both public and private (personal) benefits are involved.

Chief among the expected public benefits of widespread carpooling would be improvements in air quality. Greater use of carpools would improve air quality in two ways. One, the greater use of carpools would reduce the number of vehicles being used, thus directly reducing the amount of pollutant emissions. Second, with fewer vehicles on the road there would be less congestion and higher average speeds. Automobiles emit less pollution per vehicle-mile at higher average speeds, thus further reducing total vehicular emissions. Carpooling is more appealing and less costly than many other alternative transportation controls which could reduce air pollution.

Other advantages of increased carpooling include reduced energy consumption, monetary savings for the commuter, and the opportunity to take advantage of incentives provided for carpoolers.

Summary Evaluation of Carpool Systems

Sections III through VIII of this report have reviewed the experience with several current carpool systems in the U.S. One section has been devoted to each of several aspects of planning and operating such systems, namely (III) Matching Method and Data Base, (IV) Matching Software, (V) Organization, (VI) Marketing, (VII) Incentives and Disincentives, and (VIII) Other Issues. Content and recommendations of each section will be summarized here.

Each of these six sections included general discussion of the topic in question and specific review of actual experience with present carpool systems. Attention was focussed chiefly on the applicability of the information to carpool systems which could serve an entire metropolitan area.

Section III discussed basic carpool matching methods and data bases. Three basic organizational plans for carpool systems were defined:

1. Destination-based systems serve employees who work for one or a small number of employers at one location.
2. Regional systems serve an entire metropolitan area.
3. Combination systems combine the features of destination-based and regional systems in order to capitalize on the simplicity of destination-based systems while serving regional needs.

Destination-based carpool systems have been in use for several years. Many older systems use manual methods for matching prospective carpool partners, whereas latest systems use computer programs for matching. Most experience is with destination-based systems operated by employers to facilitate the allocation of limited parking supplies. Although the focus of this study has been regional carpool systems, some destination-based carpool systems were reviewed in this report because the experience with these systems is valuable for planning regional (or combination) systems.

These destination-based carpool systems have achieved very high vehicle occupancy compared to the national average. At Federal Highway Administration (FHWA) headquarters in Washington, D.C., an average of 2.45 persons per auto was achieved with the aid of computer matching services; higher vehicle occupancies have also been achieved in some locations. At a Burroughs Corp. plant in Pasadena, California, computerized carpool matching resulted in a 35 percent decrease in parking space demand.

Special reviews were made of five employer-operated Boston-area carpool systems. These five systems were investigated to determine what alternatives for carpool matching were utilized by employers who choose not to rely upon the computerized regional carpool system being operated by WBZ and the ALA Auto and Travel Club. All five of these employer systems involve manual or semi-automated matching systems even though up to several thousand employees are involved. All five appear to offer flexible, personal, adequate carpool matching service, but it is not possible to conclude whether these systems would be adequate if there were a greater demand for the matching service.

Experience with destination-based matching systems shows they can be effective if combined with suitable promotion and incentives. (Promotion was discussed in detail in Section VI and incentives in Section VII, both summarized below.)

Region-wide computerized matching of carpool candidates is a relatively new concept in carpools. The potential advantage of regional matching is that it can provide more people with potential carpool partners than destination-based systems usually can, which is particularly useful for employees of small firms and people who live unusually far from their place of work. This report reviews the case histories of several current regional carpool systems, all operated by or in conjunction with broadcasting stations as a public service.

WBZ radio and television and the ALA Auto and Travel Club in Boston operate what is probably the oldest and most well-known regional carpool system. This system has been heavily promoted, and all costs and effort has been donated by the private sector (largely by WBZ and ALA). By late March 1974, the system had provided computer matches to over 2800 people (out of 11,141 applicants). This response has been less than was anticipated but applications continue to arrive and the campaign will continue through at least August 1974.

Several other regional carpool systems operated by broadcasting stations were studied for this report, but all have had substantially less response than WBZ in Boston. The only regional system reviewed that has had a higher response has been a system operated by a coalition of government and private groups in the San Francisco Bay area. In a short time the San Francisco system has attracted about 25,000 applicants of which 15,000 had been processed by April first, with a high matching rate.

The regional systems reviewed for this report have provided matching service to only a small fraction of the metropolitan commuter population they are intended to serve, in spite of extensive marketing. There are no data on how many carpools have been formed as a result of these carpool systems.

Combination matching systems typically involve serving both employers and the general public, with either single or multiple data bases. These are the newest type of carpool systems, and most of those reviewed for this report have been providing matching service only to employers so far, with expansion to the general public planned for the future.

The Denver, Colorado matching system is at present being operated by the private sector, but plans are underway for a government agency to operate it. Approximately 10,000 persons from 20 firms have been serviced so far.

In Connecticut, the State Department of Transportation is providing computer matching services for carpool systems in several cities throughout the state. Local sponsors vary among the cities. Approximately

50,000 employees of 20 employers had received matching services by January 1974.

The carpool matching system in Knoxville, Tennessee, is being operated with the philosophy that carpools are part of the transit system and carpool survey data can be used to dynamically plan transit service. Approximately 20,000 carpool survey forms have been processed, and some changes have already been made in bus service.

In several other cities and states, system operation is only just beginning.

Combination systems reviewed for this report show great promise as mechanisms for both encouraging carpooling and providing the matching service needed to facilitate the formation of carpools. The most successful combination systems are characterized by enthusiastic support from a broad-based coalition of government, business leaders, and major employers.

Special purpose carpool systems for non-work trips were briefly reviewed, but appear to be attracting little interest and cannot be considered to be significant at this time.

Of the carpool systems reviewed for this report, combination systems appear to have the greatest potential for substantially increasing the auto occupancy in metropolitan areas. Within the limits of local conditions, it is recommended that a dual approach be taken to matching. Effort should be directed first at the major employers, and then the employer data should be combined (where possible) to form a data base for region-wide matching. Overall system operation should be managed by a team with broad public support.

Section IV discussed the computer programs that perform the actual matching process to identify potential carpool partners. Discussion included experience with several programs now in use.

Several types of methods for coding and matching origins (home addresses) and destinations (work locations) were reviewed. Some coding systems define zones, or grid cells, into which a metropolitan area is divided. Others us x-y coordinates or specific landmark locations. Some systems match only people with exactly the same origin and destination designation, others also search adjacent locations for additional matches.

Other criteria for matching include work schedules and personal preferences. It was concluded that the number of matching criteria should be minimized in order to prevent low matching rates, but no rigid rules can be stated. The better matching programs were found to produce reasonable matching rates with only a few thousand employees, in destination-based systems.

Privacy and security of personal data are important considerations in the matching process, so it is recommended that matching programs should provide the minimum necessary amount of output data to other applicants; home addresses, in particular, should not be disclosed.

An essential consideration is that the carpool data be readily revised, corrected, or updated to reflect such factors as changes in home or work addresses. Several methods to do this were reviewed.

Three widely-used computer programs were examined. The Federal Highway Administration (FHWA) program is probably the most widely distributed, is well documented, and is fairly effective. It appears to be somewhat limited in its usefulness for region-wide matching, however, because of its grid system, large amounts of output, and lack of efficiency for multiple-destination service.

Another widely-disseminated government-written program is that from the U.S. Census Bureau. This program is designed for use with computerized address location files, uses zone matching rather than a grid, and has been documented. Recent changes to allow its application to multiple destinations have not been documented, however.

The third program, by Burroughs Corp., uses a combination of grid cells and x-y coordinates for matching and can match for up to 99 destinations. A useful feature is a vector search technique for locating potential partners nearest the direction of travel from home to work.

Some new and less well-known programs were also studied. Of these, the most promising appears to be one written for the Denver system and this report described its operation in detail. The matching process incorporates a vector search more sophisticated than other search methods; in this mode, the computer determines the eight potential carpool partners who would involve the least extra travel distance for the applicant being matched. The program has been adapted to 20 or more firms, although it has not been documented, and is suitable for either destination-based or regional matching.

From the review of computer programs, several recommendations were made for choosing a program. For region-wide matching, the best programs appear to be the Denver, Burroughs, and Census Bureau programs, but all either have limitations or are unproven in regional use. In any case, program choice will depend upon the particular circumstances and requirements. (Sources of programs are identified in Section XII.)

Section V analyzed carpool system organizations. Three types of organizations have operated carpool systems: broadcasters, other elements of the private sector, and government agencies.

Broadcasters appear to be extremely useful in marketing carpooling and carpool matching systems, but it is questionable whether a broadcaster can enlist enough public support on its own. Employer support is important to attracting a good data base.

This report covered only one regional or combination system operated exclusively by the private sector and involving no broadcaster, namely the Denver system. While it has been effective so far, the region-wide matching is not yet in operation and plans are underway to turn the major role over to a government agency.

Government agencies operate or coordinate the systems in Knoxville, Dallas-Fort Worth, Connecticut, California, and Washington, D.C. The chief characteristic of these organizations seems to be ad hoc coordination of the private and public sectors, with the government carrying the long-term commitment for system operation. Government involvement in carpool systems is becoming more prevalent, especially because of Federal funding.

Of the systems reviewed, the most effective ones have had the strong support of employers and civic leaders. It was concluded that regional (or combination) matching systems are likely to be most successful if the system utilizes a dual approach, to both employers and the general public, to maximize the number of applicants in matching systems. It appears that a government agency should administer or oversee a region-wide system, but with broad community support. Overal organization could well be patterned after major charity drives, such as United Fund.

Total costs to initially provide carpool matching services for a metropolitan area can be estimated to be 10 to 50 cents per applicant, exclusive of maintenance, incentives and promotion.

Section VI analyzed techniques for marketing carpooling and carpool matching services. Carpooling must be actively marketed because people must be encouraged and persuaded to change their habits and form carpools.

Existing regional carpool matching systems have had varying amounts of marketing. Broadcaster-supported systems have been characterized by substantial promotional efforts, which appear to have been effective at making the public aware of the system. Low response rate from the public may result from lack of support from employers or lack of incentives.

Destination-based systems, and the employer portions of combination systems, have often been heavily marketed within the employer organization. Support of top management, coupled with widespread publicity, have resulted in response from 50 percent or more of the employees.

It is recommended that both public and internal employer promotion be used with the recommended dual approach carpool systems. To this end, the report presented suggestions for marketing the system to employers, employees, and the general public.

Major employers and other civic leaders from the private sector should be involved with the carpool system beginning in the planning stage. Support should be solicited from industry, commerce, and labor, and especially from membership organizations representing these elements. Employers should be shown the benefits to them of carpooling among their employees, such as reduced facility costs and improved public relations.

Employees should be approached through a comprehensive, personalized marketing effort fully supported by their company management. Benefits to them of carpooling, and special incentives available, should be well publicized. Overall, the carpool system could be marketed in a manner similar to that used for major in-house charity drives or other employer activities.

The marketing plan for the general public must be tailored to the local circumstances. The leadership is particularly important, as it should be professional, popular, and committed. Media involvement is essential, and consideration should be given to allowing a single broadcaster organization to exclusively provide the broadcasting portion of promotion.

Before marketing is begun, local professionals should be invited to help develop the marketing plan (and the overall system).

Promotion should inform the public, demonstrate the benefits of participation, and persuade people to join. Providing questionnaires and collecting data should be free of cost to the participants and questionnaires should be simple to complete.

The entire marketing program, especially survey forms and associated maps, should be tested before widespread use, to ensure their adequacy.

Section VII reviewed incentives and disincentives which can be explicitly provided to encourage carpooling. With the desination-based carpool systems in use for some time, the most commonly used incentive has been preferential parking. Few regional or combination systems have incorporated any explicit incentives. Limited experience to date shows that incentives can increase carpooling and should be given serious consideration in planning carpool systems, but few data are available to indicate the effectiveness of specific incentives. The utility of incentives was demonstrated, however, by the markedly increased interest in carpooling during the gasoline shortages of January to March, 1974. A wide variety of incentives can be provided, so it is essential to have a cohesive plan for coordination among employers and with public agencies.

Employers have an important potential as a source of incentives. Available major incentives include preferential parking, loading areas, direct monetary subsidy, flexible work schedules, and provision of vehicles.

Incentives for the general public encompass a broader range and influence many more drivers than can employer-provided incentives. Public incentives generally require detailed case-by-case analysis, however, because of their potential widespread effects.

Preferential treatment of carpools on highway facilities has been shown to increase the number of carpools using a facility. Techniques include exclusive lanes, reduced tolls, and preferential bypass of queues at congestion points. These reduce the cost or travel time for carpools compared to single-occupant vehicles. Detailed technical analysis is necessary to insure that such devices do not produce counter-productive effects on non-carpool traffic.

Preferential treatment in parking supply, cost, or availability should effectively be coordinated with employers' preferential parking for carpoolers so that together nearly all employees in a region would be treated equitably. Parking regulation appears to have the greatest potential for widespread use as an incentive to carpooling of the incentives studied.

Incentives have the potential for assisting the operation of a carpool system, especially in the beginning. Incentives should be well planned and well publicized; and provided to the general public, employees, and employers.

Section VIII discussed several miscellaneous issues related to carpooling.

Most carpool systems would not be expected to encounter serious legal difficulties, but carpool systems should be reviewed for several legal issues to ensure compliance with local laws and regulations. Carpool system operators should urge carpoolers to inform their auto insurers and to verify the adequacy of their insurance protection for carpools. Insurers are moving towards lower rates for carpoolers and generally appear to support the carpooling concept.

Planners of carpool systems should anticipate the need to coordinate their systems with operators of taxis and transit systems. Carpool surveys can provide data useful for dynamically planning transit system operations. Carpoolers should also be encouraged to use transit systems, and transit and taxi operators should be shown how increased carpooling can lead to increased use of their services. That this can be done is demonstrated by Knoxville, where the transit commission is helping to organize the carpool system.

Planning of carpool systems should include provisions for measuring the changes in carpool usage. At present, few data are available to correlate carpool use with carpool system operation. Obtaining such data, through techniques such as mail surveys, would enable design of more cost-effective carpool systems.

Section IX briefly reviewed several more theoretical aspects of carpool system planning and explored the relationship of carpool systems to the transportation planning process.

A review of literature on auto occupancy showed that the amount of carpooling is less than one would expect based on only average auto occupancy data. At present, about 28 percent of all commuters travel in vehicles with two or more people. Only about half of the vehicles with two or more occupants are actually carpools used for commuting on a regular basis. Increasing commuting auto occupancy by 50 percent (from 1.2 to 1.8 persons per vehicle) would reduce commuter travel by about one-third, but to achieve this increase would require increasing the proportion of commuters who travel in multiple-occupancy vehicles from 28 percent to 73 percent, or to nearly three times the present rate.

Increased carpooling could alter the division of commuters among travel modes (mode split). It is possible that widespread carpooling may shift some commuters away from transit. On the other hand, ridership on some specific lines could be increased by coordinating carpooling and transit service. Also, off-peak transit use may increase as carpooling reduces the number of people without their own cars in employment centers.

Carpooling could also alter travel times on highway routes and thus alter the distribution of traffic throughout the transportation network.

There is some evidence that carpooling would alter overall travel patterns because carpoolers differ in their travel characteristics from non-poolers; they tend to drive further and work for larger firms than does the "average" driver, for example.

There is only a limited basis at the present time for predicting (1) the number of applicants to a matching service who will receive useful matches, (2) the number of persons who would form carpools after receiving lists of potential carpool partners from a matching service, (3) the amount of actual travel reduction that would occur as a result of the carpools formed, and (4) the concomitant improvement in air quality. Some analytical work on these questions has been reviewed in this report, but more research and more experience are both needed. Some further research on these topics is underway or planned.

RECOMMENDATIONS

From the study undertaken for this report and summarized in this section, several major recommendations are offered. (Detailed recommendations on certain aspects of planning carpool systems are also contained in Sections III through VIII, and were summarized in the earlier portion of this Section.)

1. To be effective, carpool systems should be combination systems with the dual foci of employers and the general public. Employers should be involved because experience shows destination-based systems are much more effective than regional systems. The general public should be involved because the people who most need the carpool matching service are those who work for small employers or live unusually far from their place of work and thus are least well served by destination-based systems.
2. Carpool system organization should be tailored to the community, but as a rule should include a broad representation of the public and private sectors. Overall organization could well be based upon major charity drives such as the United Fund.

3. Carpooling and carpool systems must be actively marketed in order to alter people's long-standing habit of driving alone to work. Simple publicity will not suffice, and professional marketing guidance should be sought for each system.

4. Incentives should be provided to encourage carpooling. A wide variety of incentives is available, and those used should be suitable for local circumstances and coordinated between the employers and the public agencies. Parking regulation has major potential.

5. Additional study and research is needed to understand and plan effective carpool systems, because little experience with these systems has yet been documented. A major need is for an understanding of how many carpools are actually formed with the various carpool systems. Research should be undertaken to investigate the carpool formation rate from several regional or combination carpool systems.

SECTION XI

REFERENCES

1. 42 United States Code 1857 et seq.

2. Public Law 93-239, January 2, 1974.

3. U.S. Department of Transportation. National Transportation Energy Conservation Action Plan/Executive Summary. (Presented at DOT Carpool Seminars. February 1974.) Photocopied.

4. Federal Register. 38:30966-30967. (40 C.F.R. 52.1138)

5. The Conservation Foundation. A Citizen's Guide to Clean Air. The Conservation Foundation, Washington, D.C. January 1972.

6. Kendall, D. and J. Brevard. Auto Occupancy and the National Level of Carpooling. U.S. Department of Transportation, Transportation Systems Center, Cambridge, Mass. Report No. RP-SA-13. December 28, 1973.

7. Highway Users Federation for Safety and Mobility. News Release. August 29, 1973. Photocopied.

8. Transit and Traffic Engineering Branch, Urban Planning Division, Federal Highway Administration, U.S. Department of Transportation. Carpooling Case Studies. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. January 1974.

9. Alan M. Voorhees and Associates, Inc. Organization for Carpooling. U.S. Department of Transportation, Washington, D.C. January 1974.

10. Pratsch, L. Carpool and Buspool Matching Guide. Third Edition. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. November 1973.

11. Personal communication. Personnel at Station WBBM, Chicago. March 18, 1974.

12. Alan M. Voorhees and Associates, Inc. Manual Carpool Matching Methods. U.S. Department of Transportation, Washington, D.C. January 1974.

13. Station WBZ. WBZ's Commuter Computer Clubcar. Press kit. Boston, 1974.

14. Heaton, C. Preliminary Evaluation of the Boston Area Carpooling Program (WBZ/ALA Commuter Computer Clubcar Campaign). U.S. Department of Transportation, Transportation Systems Center, Cambridge, Mass. Report No. RP-SA-10. December 11, 1973.

15. Personal communications. Personnel at WBZ, ALA, Associated Industries of Massachusetts, Massachusetts Executive Office of Transportation and Construction, and Federal Highway Administration Division Office. January, February, and March 1974.

16. Station WIND. The WIND Commuter Computer. Press kit. Chicago, 1974.

17. Personal communications. Personnel at WIND, and ADP of Chicago and Boston. March 1974.

18. Personal communications. Personnel at KDKA and Southeastern Pennsylvania Regional Planning Commission, Pittsburgh. March 1974.

19. Personal communications. Personnel at Keystone Auto Club, Philadelphia. March 1974.

20. Personal communications. Personnel at FHWA Regional Office and Hoefer/Amidei Assoc., San Francisco; and California Department of Transportation, Sacramento. March 1974.

21. Personal communications. Personnel at WJZ-TV, Baltimore. March 1974.

22. Rocky Mountain AAA. The Care and Feeding of a Carpool. Instruction kit. Denver, February 1974.

23. Personal communications. Personnel at George Washington High School; Downtown Denver, Inc.; EPA Region VIII; Air Force Accounting and Finance Center; all in Denver. February and March 1974.

24. City of Dallas. Car Pool. Information kit. Dallas, Texas, 1974.

25. Personal communications. Personnel at Dallas Traffic Control Department. March 1974.

26. Connecticut Department of Transportation. Planning for the Future. Part III: Expressway Interchange Parking Study in Connecticut. Connecticut Department of Transportation, Hartford, Connecticut. November 1970.

27. Personal communications. Personnel at Connecticut Department of Transportation. January, February, and March 1974.

28. Personal communications. Personnel at Metropolitan Washington Council of Governments. February and March 1974.

29. Alan M. Voorhees and Associates, Inc. Review of Matching Software and Procedures. U.S. Department of Transportation, Washington, D.C. January 1974.

30. Personal communications. Personnel at Office of Mayor and University of Tennessee, Knoxville. February, March, and April 1974.

31. Personal communications. Personnel at California Department of Transportation, Sacramento. March 1974.

32. California Department of Transportation. Car Pool Program Implementation Plan. First Revision. Department of Transportation, Sacramento, California. February 15, 1974. Photocopied.

33. Alan M. Voorhees and Associates, Inc., and Behavior Science Corporation. A Study of Techniques to Increase Commuter Vehicle Occupancy on the Hollywood Freeway. For: California Department of Transportation. November 5, 1973.

34. Ups and Downs of Car-Pooling. New Scientist. p. 760-761. March 21, 1974.

35. Personal communication. Personnel at Star Markets, Boston, Massachusetts. March 1974.

36. U.S. Department of Transportation, Federal Highway Administration, Public Transportation Branch. Estimating Auto Occupancy: A Review of Methodology. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. 1972.

37. Highway Users Federation for Safety and Mobility. The 'Pool It' Work Kit. Highway Users Federation for Safety and Mobility, Washington, D.C. 1974.

38. U.S. Department of Commerce, Census Use Study, and Southern California Regional Information Study, County of Los Angeles. CARPOL/an approach to large-scale carpooling using DIME technology. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. January 1974.

39. Burroughs Corporation. Operation Energy. Burroughs Corporation, Detroit. 1973.

40. Alan M. Voorhees and Associates, Inc. Incentives to Carpooling. U.S. Department of Transportation, Washington, D.C. January 1974.

41. Alan M. Voorhees and Associates, Inc. Legal and Institutional Issues of Carpooling. U.S. Department of Transportation, Washington, D.C. January 1974.

42. Alan M. Voorhees and Associates, Inc. Transit/Taxi Coordination. U.S. Department of Transportation, Washington, D.C. January 1974.

43. TRW, Inc. Socio-Economic Impacts of the Proposed State Transportation Control Plans: An Overview. U.S. Environmental Protection Agency, Durham, N.C. November 1973.

44. Berry, W. L. Regional Carpool Matching Programs: A Simulation of the Boston Experience. Harvard College, Cambridge, Mass. 1974. Unpublished paper.

45. Kendall, D. Planning for Carpool Matching Services. U.S. Department of Transportation, Transportation Systems Center, Cambridge, Mass. Report No. RP-SA-18. February 6, 1974. Photocopied.

46. Pratsch, L. Carpools: The Underutilized Resource. Civil Engineering. 44:49-52. January 1974.

Note: Personal communications include correspondence, telephone conversations, and meetings.

SECTION XII

ANNOTATED BIBLIOGRAPHY

This section lists and describes the contents of selected literature of major interest to those responsible for planning and analysis of carpooling and carpool systems. Sources for key documents are also listed.

Alan M. Voorhees and Associates, Inc. Buspools. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Criteria for and organization of buspools. Buspools viewed as larger version of carpools or vanpools. Good description of case histories of several buspool programs.

Alan M. Voorhees and Associates, Inc. Incentives to Carpooling. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Useful summary of the advantages (and disadvantages) of several types of incentives. Includes a tabulation of which incentives are useful for various types of sponsors (government, employer, etc.), and information on relative costs.

Alan M. Voorhees and Associates, Inc. Legal and Institutional Issues of Carpooling. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Questions and conclusions regarding: legal aspects of incentives, expense sharing, liability, competition; security; compensation; insurance.

Alan M. Voorhees and Associates, Inc. Manual Carpool Matching Methods. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Describes noncomputerized methods for organizing systems to match people for carpools. Intended for organizations with 100 to 1,000 personnel. Describes the mechanics of several methods in moderate detail and gives examples of existing manual employer systems. Includes information on costs, incentives, and problems. Should be reviewed by any organization undertaking an employer-based carpool program, because these manual methods may suffice even for employers with 1,000 employees or more, depending upon employer and location.

Alan M. Voorhees and Associates, Inc. Organization for Carpooling. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

How to organize a carpool/buspool/vanpool program. Descriptions of several existing organizational arrangements. Tabulation of carpool organizations in 25 U.S. cities. Emphasis is on employer-based programs or on single destination areas, not regional programs.

Alan M. Voorhees and Associates, Inc. Review of Matching Software and Procedures. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Description and analysis of nine computer programs for performing carpool matching, with brief outline of 13 additional programs. Identified characteristics of each program include computer language, computer core size needed, source of program and status of documentation, name of person to contact, etc.

Alan M. Voorhees and Associates, Inc. Transit/Taxi Coordination. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Discusses coordination of carpool campaigns with transit and taxi operators to help ensure maximum overall efficiency of the transportation system and to minimize possible problems for transit and taxi operators from large-scale carpool efforts. Important reference for government agencies desiring to sponsor carpool programs because it points out problems and shows how to minimize them.

Alan M. Voorhees and Associates, Inc. Vanpools. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Presents discussion of methods for organizing carpool programs based upon 7- to 15-seat vans instead of sedans. Outlines problems and solutions. Covers programs in which vans are owned by employers, riders, individuals, or other agencies. Probably of greatest value to employers considering vanpools as part of carpool program.

Alan M. Voorhees and Associates, Inc., and Behavior Science Corporation. A Study of Techniques to Increase Commuter Vehicle Occupancy on the Hollywood Freeway. For California Department of Transportation, Sacramento, California. November 5, 1973.

Report of a study which used the Hollywood Freeway for research on commuter behavior, potential for carpooling, and methods for increasing commuter vehicle occupancy. Included: a useful review of carpool literature; behavioral survey of present Hollywood Freeway commuters, including exploration of psychological differences between carpoolers and nonpoolers; evaluation of 16 techniques for motivating carpooling; recommended program of action on carpooling by California.

Berry, William L. Regional Carpool Matching Programs: A Simulation of the Boston Experience. Harvard College, Cambridge, Mass. 1974 (unpublished paper).

Analysis of the travel characteristics of the first 6,000 responses to the WBZ-ALA carpool matching service in Boston. Computer simulation of how the WBZ-ALA matching service would operate with varying numbers of additional applicants. Discussion of the effectiveness of such carpool systems. (Author is a research assistant in the Graduate School of Business Administration; further research is planned.)

Burroughs Corporation. Operation Energy. Book 1: Management Guidelines. Burroughs Corp., Detroit, Mich. 1973. (Source: B.)

Brief but comprehensive manual for organizing a carpool program. Includes discussion of the computer program (described in detail in Book 2), Burrough's experience, organization and implementation of carpool program, incentives, sample questionnaires. Available free from Burroughs Corp., Burroughs Place, Detroit, Mich. 48232.

Burroughs Corporation. Operation Energy. Book 2: Program Documentation. Burroughs Corp., Detroit, Mich. 1973. (Source: B.)

User and program documentation for a computer carpool matching program, CARPOL, developed by Burroughs. Written in ANSI COBOL (higher level), reported by USDOT (Reference 29) to require 20,000 bytes of core. Based upon a grid system of map coordinates for residences, up to 99 coded destinations. Uses a vector search if specified number of matches is not found in home grid cells. User can specify number of potential matches, number of grids to search.

Connecticut Department of Transportation. Bureau of Planning and Research. Division of Transportation Planning. Planning for the Future; Part III: Expressway Interchange Parking Study in Connecticut. Connecticut Department of Transportation, Hartford, Conn. November 1970.

Report of survey of extra-legal, ad hoc parking at highway interchanges in Connecticut. Survey showed that the majority (93.6 percent) of such parking was for work trips, most of which (88 percent) were completed by carpool. Discussion of need for and recommendations on formal provision of interchange parking facilities to encourage carpools.

Heaton, Carla. Preliminary Evaluation of the Boston Area Carpooling Program (WBZ/ALA Commuter Computer Clubcar Campaign). Cambridge, Mass.: U.S. Department of Transportation, Transportation Systems Center, Cambridge, Mass. Report No. RP-SA-10. December 11, 1973.

A preliminary, internal research paper with analysis of the first 4 months of operating the WBZ/ALA campaign. Useful examination of origins, destinations, and work times of first 4,600 respondents to campaign. Also includes extensive bibliography on carpooling; many of the references are nontechnical items (newspaper or general circulation magazine articles, for example).

Highway Users Federation for Safety and Mobility. The "Pool It" Work Kit. Highway Users Federation, Washington, D.C. 1974. (Source: C.)

Handbook for planning and operating carpool systems, directed mainly at employers. Generally less detail than in FHWA report series. Contents; introduction, overview, types of ride pools (car, bus, and vanpools are discussed), planning a carpool program, motivation (incentives), public information and promotion, matching (duplicates much of FHWA literature on matching computer programs), legal aspects; lists of Federal Energy Office Regional Administrators, DOT Secretarial Representative, DOT Division Engineers, HUFSAM Regional Representatives.

Kendall, Donald. Planning for Carpool Matching Services. U.S. Department of Transportation, Transportation Systems Center, Cambridge, Mass. Report No. RP-SA-18. February 6, 1974.

A preliminary, internal research paper that discusses the mathematical basis for matching carpool candidates. Includes a model for estimating the number of matches from a given set of circumstances.

Kendall, Donald and Joe Brevard. Auto Occupancy and the National Level of Carpooling. U.S. Department of Transportation, Transportation Center, Cambridge, Mass. Report No. RP-SA-13. December 28, 1973.

A preliminary internal research paper with analysis of the national statistics on automobile occupancy and carpooling. Examines the distribution of commuters by number of vehicle occupants and discusses effectiveness of various postulated changes in auto occupancy. Concludes that relatively large increases in amount of formal carpools would be needed to achieve modes increases in average vehicle occupancy.

Meyers, Phil and John Walker. The Effects of 'Share a Ride Day' on Los Angeles Freeways. Traffic Engineering. 72 (11): 35-37, August 1972.

Description of experiment to increase vehicle occupancy through public relations campaign. No apparent increase in vehicle occupancy occurred. Detailed tabulation of vehicle occupancy data for three freeways.

Morin, Donald A. Commuter bus clubs are showing the 'professionals' how to meet transit demand. Traffic Engineering. 44 (4): 24-27, January 1974.

Description of experience with buspools organized by commuters, and criticism of transit systems' failure to meet demand.

Pratsch, Lew. Carpool and Buspool Matching Guide. 3rd edition. In DOT Carpool Seminar. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. November 1973. (Source: A or D.)

Overview of how to organize carpool or buspool campaign. Includes description of successful carpool, vanpool, bus programs. Describes public information, incentives, matching and maintenance. Includes a short bibliography of publications on carpools and buspools. General emphasis is on employer-based carpool schemes and the DOT/FHWA matching program in particular.

Pratsch, Lew. Carpools: the underutilized resource. Civil Engineering. 44: 49-52, January 1974.

Essay on the values of carpools to society and the individual. Some estimates of the impact of massive carpooling on highway congestion, air quality, fuel consumption. Useful as an overview of the potential advantages of widespread carpool programs.

U.S. Department of Commerce, Census Use Study and Southern California Regional Information Study, County of Los Angeles. CARPOL/an approach to large-scale carpooling using DIME technology. U.S. Department of Commerce, Bureau of the Census, Washington, D.C. January 1974. ($3.) (Source: D or E.)

Report from Census Use Study. Describes a project to use a computer program to generate lists of carpool candidates for employees in Los Angeles Civic Center. Program (CARPOL) is written in FORTRAN, is available to public, and at present is limited to one destination. Flexible matching criteria (variable geographic area for matching origins). Report includes detailed description of L.A. experience, including costs and times, plus user documentation for CARPOL. Designed for use with Census DIME files (information relating street addresses to geographic grid system) but can be used with other types of geographic coding of origins. Report includes description of a method for manual conversion of topological information (such as boundaries of census tracts or zip codes) to mathematical coordinates for use with computer program.

U.S. Department of Transportation. DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. 1974. (Source: A)

Ring-bound collection of materials provided to participants in DOT carpool seminars throughout the U.S. during early 1974. Includes several booklets separately listed in this bibliography, plus other materials on preferential treatment of multiple-occupancy vehicles, legislation, and public relations literature.

U.S. Department of Transportation. National Transportation Energy Conservation Action Plan/Executive Summary. Paper presented at DOT Carpool Seminars. February 1974 (photocopied).

Summary of the administrative actions by DOT to reflect the Emergency Highway Energy Conservation Act. Specifies types of funds available for energy-reduction transportation projects (such as carpool matching systems) and outlines requirements for regional emergency transportation programs. Includes text of relevant sections of the Act.

U.S. Department of Transportation. Federal Highway Administration. Computer Services Division. Mission Support Branch. Program Documentation for the FHWA Carpool Matching Program. In DOT Carpool Seminar. U.S. Department of Transportation, Washington, D.C. January 1974. (Source: A.)

Detailed description of the internal operation of the FHWA matching program. ("Available upon request from the Urban Planning Division on a limited basis.")

U.S. Department of Transportation. Federal Highway Administration. Urban Planning Division. Public Transportation Branch. Estimating Auto Occupancy: A Review of Methodology. U.S. Government Printing Office, Washington, D.C. 1972 (stock number 5001-0035). (Source: D.)

How auto occupancy data is used in transportation planning. Determination of average auto occupancy. Modeling methods. Good compilation of average auto occupancy used in part studies, including variations by city, year, trip purpose, land use, distance, car ownership; but much of data are several years old. Twenty-five references.

U.S. Department of Transportation. Federal Highway Administration. Urban Planning Division. Transit and Traffic Engineering Branch. Carpooling Case Studies. In DOT Carpool Seminar. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. January 1974. (Source: A.)

Description and analysis of carpool programs organized at the Federal Highway Administration Headquarters in Washington, D.C., in 1972, and at the Baltimore Federal Executive Board offices in 1973. A total of 1,200 employees at the Baltimore office. Report includes sample questionnaires, publicity materials, and results. (Both cases involved the FHWA computer program.)

U.S. Department of Transportation. Federal Highway Administration. Urban planning Division. Transit and Traffic Engineering Branch. User Documentation for the FHWA Carpool Matching Program. In DOT Carpool Seminar. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. January 1974. (Source: A.)

Guide for operating the FHWA matching program. Describes how to obtain the program, how to establish grid system, logic of matching process, input and output, and operating the program. Probably most widely used program, and has been adapted to several computers. Requires a maximum core capacity of 122K, or less without certain optional features; written in ANSI COBOL. Suitable for regional use in that multiple destinations can be specified, but some users find not enough geographic detail can be specified in the grid system.

Zevin, Israel. Carpooling in Connecticut. Connecticut Department of Transportation, Division of Planning, Traffic Statistics Section, Hartford, Conn. April 1972.

Results of several surveys to determine the present carpooling habits of commuters. Analysis of Hartford traffic study to show passenger car occupancy as a function of commuting distance, type of employer. Analysis of special counts of vehicle occupancy among several types of employers throughout Connecticut, including data on effect of population and other factors on occupancy. Analysis of survey of vehicle occupancy at fringe parking lots.

Sources for obtaining published materials:

Source A (DOT Carpool Seminar reports)

Available at no charge from either the FHWA Division offices located in the capital city of each state, or from:

Urban Planning Division HHP-26
Federal Highway Administration
Washington, D.C. 20590

Source B

T.S. Grier, Coordinator
"Operation Energy"
Burroughs Corporation
Burroughs Place
Detroit, Michigan 48232

Source C

Highway Users' Federation
1776 Massachusetts Avenue, N.W.
Washington, D.C. 20036

Source D

U.S. Government Printing Office
Washington, D.C.

Source E

Users' Service Staff
Data Users Office
Bureau of the Census
Washington, D.C. 20233